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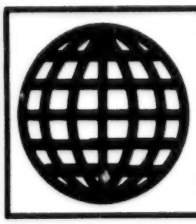

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Holonic Mechanism Concept for Micromachines Described

946C3823A Tokyo JSME in Japanese Dec 92 all pp

[Article by Takeo Onishi, Yutaka Ozawa, Tomoyoshi Ibe and Tetsuji Hayashi, Mitsubishi Heavy Industries Ltd.]

[FBIS Translated Text]

1. Foreword

Micromachine technology has recently been attracting attention as new machines. This technology is expected to be one of the main technologies of the 21st century, and active research is under way. The Ministry of International Trade and Industry (MITI) launched a large-scale project in 1992 as part of such efforts. These efforts are aimed at developing micromachines and exploring their possibilities. Research is under way to develop manufacturing technology to achieve miniaturization, very small function element technologies (actuators, sensors, etc.) and technology to operate them.

However, the functions of micromachines deteriorate sharply as they become smaller, and it becomes difficult to give them intentional operation functions required. In order to solve this problem, it is necessary to develop new mechanisms and control systems that take into account characteristics of very small structures and systems. It is important to use these mechanisms and systems together with miniaturization technology in a bid to develop a new, attractive field. As functions of discrete micromachines are limited, it is effective to group micromachines into a colony. Based on this concept, a multi-agent system[1] and group control based on behavior control[2] have already been proposed. Self-organized robots (cellular robots) designed to achieve intended functions by combining many function elements (mechanical modules) have also been proposed.[3] Simply put, these ideas aim at attaining a goal by dispersing various functions needed for the goal to discrete machines grouped into a colony. These ideas are very challenging and require high-level research, but some kind of integration method will become necessary as there are too many combinations of function elements. Based on the idea of robot groups, we have built a concept of a new mechanism (holonic mechanism) and its control method (organizational colony control/ morphological control for transformation, or form changing control) and studied mechanism forming, which will be briefed here.

We have been doing research on colony control since this fiscal year, based on the concept introduced here, as a research project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

2. Basic Concept of Holonic Mechanism

Figure 1 shows the basic concept leading to the holonic mechanism. Colonies are classified into those with weak links, exemplified by the cooperative work of ants, and those with strong links in which elements of the same mechanism are grouped to achieve a different function as a colony, such as coral and muscles. A strong-link colony can be called a group with hard links, so to speak. It might be easier to understand the concept proposed here if such a colony is explained as a combination (holonic mechanism) of functional elements of the same or similar functions (holons). Thus this proposal can be defined as follows:

Basically a functional body having a mechanism in which many of the same or similar functional elements are hard-linked.

3. Method to Materialize the Concept

3.1 Example of Basic Forming of Holonic Mechanism

As a micromachine should be able to operate, it is effective to form it with holons with some kind of driving element. Figure 2 is an example of a holonic mechanism made by linking holons in series (serial-link holonic mechanism, or SLHM) with one of forming methods and then linking these SLHMs in parallel at some section of the SLHMs (parallel-link holonic mechanism, or PLHM). This mechanism can have surprisingly various potential functions (its shape can be changed into a spider or an octopus—an example of holonic octopider-4-PLHM).

But several technical problems must be solved before realizing it.

3.2 Cableless Link and Micro-OS

Conventional connecting of machines requires an electrical link via cable in addition to a mechanical link, limiting the degree of freedom and deteriorating reliability. As the machine size becomes smaller, the cable's ratio of driving resistance increases, making it difficult to develop a mechanism. Therefore, the following two ideas should be introduced to reduce the mechanism's mechanical and electrical constraint in order to drastically improve the possibility of linking many holons (Figure 3).

3.3 Form Changing

Another problem that needs to be solved in order to make a holonic mechanism functional is flexible control of a superhigh-degree-of-freedom system. At present, there is no general solution to controlling, including practical calculation time, of a joint with a superhigh degree of freedom.

Here, several basic forms will be given to form changing control (holonic mechanism) and we will realize an intended function by controlling only the required joints, without altering these forms. In other words, we aim at making more existing control rules applicable by degenerating the degree of freedom according to functions.

Figure 4 shows examples of holonic mechanism operation under form changing control.

4. Holonic Mechanism Forming

Methods of forming a holonic mechanism requires detailed research and development of the number of links, connection systems and methods (forming of the degree of freedom and connection between degrees of freedom), and their effects. An example of a preliminary study is explained below.

4.1 Forming SLHM

In forming an SLHM, there are two basic mechanism formations for each holon—rotating and bending. As for connecting, there are principal axis and inclined axis connections (Figure 5).

4.2 Example of SLHM Forming

The adoption of the rotating-type mechanism is possible from the viewpoint of early realization. Examples of rotating-type mechanism forming and connection are shown in Figure 6.

In (a) and (b), the rotating axes of adjoining holons cross each other at a right angle, while these axes are mutually inclined in (c). We plan to study three-dimensional shape forming and its control from the viewpoint of form changing function.

5. Preliminary Verification and Outlook

In order to evaluate, if only partially, holonic mechanism forming methods and the possibility of form changing control, we carried out a form changing simulation of the holonic octopider based on the three kinds of SLHM formation shown in Table 1 and a simulated experiment on its functions (Figure 7).

We confirmed that even a mechanism made by connecting rotating-type holons shown in Figure 6 can have considerably flexible forms.

Thus we judged it worthwhile to try to realize this proposal. We need to conduct detailed research and development of the following three, which are more specific and have general applications:

(1) Holonic mechanism forming

The number of links, connection types, methods and effects.

(2) Connection

The realization of intelligent connectors and micro-OS.

(3) Realization of form changing control

6. Conclusion

We thus proposed the concepts of holonic mechanism and form changing control as a new machine system to develop intentional operation functions of micromachines and introduced their effectiveness and methods of realization.

As for holonic mechanism forming, we provided several specific examples based on rotating-type mechanism.

7. Afterword

In the field of micromachines, actual development lags behind words. Active proposals are called for regarding the newness of the technology and functions beneficial to human beings.

In the technological aspect, micromachines could depend too much on integrated circuit manufacturing technology and they could fail to show their characteristics fully in practical use. We firmly believe that the system proposed here is a very effective concept that can provide answers to these problems. But we also have to admit that there exist many other methods to put micromachines to practical use.

We are therefore exerting efforts to find as many solutions as possible. We hope research will be done on these methods to achieve a practical micromachine as soon as possible.

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Tokyo Institute of Technology Develops Transparent Polycrystal Thin Film

4307002?A Tokyo THE NIKKEI WEEKLY in English 19 Dec 94 p 12

[FBIS Transcribed Text] The use of synthetic diamond as high-performance optical materials moved a step closer recently with the report of a new method for fabricating transparent sheets of polycrystal diamond, developed by a group from the Tokyo Institute of Technology.

Because diamond exhibits high thermal and chemical stability and transmits the widest range of light wavelengths of any solid, it is an ideal material for use in several optical applications.

However, natural diamond is far too expensive, and the polycrystal diamond sheets synthesized to date are marred with impurities and crystal defects that impede the transmission of light.

The new synthesis method produces thin diamond films consisting of very small and densely packed polycrystal diamond particles.

It is this feature which the researchers believe makes their diamond sheets transparent.

In the method, argon, hydrogen and methane gases are injected at supersonic speed into the arc discharge between two electrodes, and carbon deposits out on a heated substrate.

By keeping the concentration of hydrogen gas to less than 1 percent that of methane, and by controlling the rate of diamond synthesis to around 0.01mm per hour, the researchers were able to grow diamond thin films that are clear, not opaque.

Practical Uses

Using a methane gas concentration of 0.6 percent, the group fabricated a polycrystal diamond sheet several tenths of a millimeter thick.

The transparency of the diamond depends on the wavelength of light tested, but in the best case transmissivity reached nearly 70 percent, which is good enough for practical use in optical applications.

Sumitomo Electric Develops Ceramic Micromachining Technology

95P60111A Tokyo NIKKEI SANGYO SHIMBUN in Japanese 14 Feb 95 p 1

[FBIS Translated Text]

Using Synchrotron Radiation

Sumitomo Electric Industries, Ltd. has developed micromachining technology for ceramics using synchrotron radiation (SR). Diamond grinding is limited to approximately the 100 micron (1 micron equals 1/1000 millimeters) level. However, the newly developed SR micromachining is capable of a level just a little over 10 microns. Application of this technology will enable production of micromachine parts useful for inspection of the fine tubing in nuclear power plant steam generators and fine ceramic filters in the medical field. The new technology also can be used for metals as well as ceramics. It opens new opportunities to produce fine mechanical parts, including micro gears.

Sumitomo Electric received a contract for the research through the Micromachine Center, a non-profit organization under the jurisdiction of the R&D project "Research and Development for Micromachine Technology" administered by the New Energy and Industrial Technology Development Organization (NEDO). Sumitomo has been using the small "NIJI-III" SR superconducting equipment located at their Harima Laboratory.

The shape of the parts are burned on the resist using SR and the resist mold is produced through lithography. Ceramic slurry containing ceramics, solvent, and additive is injected into the mold. When the slurry is solidified, the plasma etching is applied to remove the resist and sintering is administered.

SR features the ability to sensitize the resist deeper than using ultraviolet beams. However, depth was still limited through use of small SR equipment that emits relatively long wavelength light of a maximum of about 5 Angstrom (1 Angstrom equals 1/10 million millimeters). Sumitomo Electric has developed its own high sensitivity resist which allows application of deep lithography even when using the small SR equipment. Sumitomo produced a resist mold which contains many perpendicular openings 150 microns deep and 20 microns in diameter. Using this mold, Sumitomo was able to fabricate an array of 1,700 microfine ceramic columns per 1 square millimeter. They each measured 17 microns in diameter and 120 microns in height.

Sumitomo Electric for now intends to develop a micromachine which functions under water. By using the prototype array as a compound piezoelectric vibrator (a device that vibrates when voltage is applied), Sumitomo is planning to produce a 1mmx1mm ultra small submarine signal transmitting device.

The compound piezoelectric vibrator can also be used for ultrasonic medical diagnostic equipment and as a catheter for blood vessels. Furthermore, other possible applications include blood plasma separation for medical purposes and various high separation capable ceramic filters.

Once a resist mold is made, parts can be mass produced. Materials other than ceramics can be used for making ultra small parts. Therefore, the parts may be used in applications such as in fiber optic switches and micro connectors in the communications field which used to be hard to make.

Sumitomo Electric has been conducting the SR research since they opened their Harima Laboratory in January 1994. The latest development of micro lithography technology is their number one research achievement. At present they also are conducting experiments on the synthesis of mono crystal diamond film.

National Lab Develops High Strength, High Toughness SiN Ceramics

95P60111B Tokyo KAGAKU KOGYO NIPPO in Japanese 14 Feb 95 p 8

[FBIS Translated Text]

Sheet Formation Requires No Pressurization

The Structural Ceramics Laboratory at the National Industrial Research Institute of Nagoya, the Agency of Industrial Science and Technology (AIST), has developed a high strength, high toughness ceramic. The lab developed the silicon nitride (SiN) ceramic with 1200MPa strength and 12MPa toughness in the direction vertical to the orientation surface by forming a sheet from a slurry which consisted of starter powders and columnar structured SiN seed crystal. The key to the success was proper control over the columnar seed crystal growth during the burning stage. The Weibull coefficient was confirmed to be 50 which is about the same as that of cast iron. This technology will expand the application potential of structural ceramics, thus attracting much attention.

Weibull Coefficient Equal to That of Cast Iron

SiN is highly covalent and stable at high temperatures, and therefore is considered the most promising ceramic for high temperature structural material. Arrangements are now under way to use the material in engine components such as turbo charger rotors for automobiles. However, it has a 10-fold lower fracture toughness than metal materials. That is one reason why ceramics are considered unreliable and why they require improvement.

Research to improve the material's properties through composition control during processing has been under way as part of the National "Synergy Ceramics" Project administered by AIST's National Industrial Research Institute of Nagoya. The latest development was made under this project.

The technology to improve toughness without lowering strength by controlling the size and distribution of columnar particles which grow in the sintered body after adding mono crystal beta-SiN particles as the seed crystal with the starter powder had already been developed in 1994. This technology was further pursued for other applications using the sheet forming method. The seed crystal was a mono crystal beta-SiN of 1 micron in width and 4 microns in length. The starter powder was alpha-SiN. Two percent seed crystal was added to the starter powder and then made into slurry. The slurry was then stretched out into 60 layers of sheets 100 microns each in thickness over the carrier film and then heated at 100-120°C and pressed into compact form. After calcination, the compact was sintered at 1,850°C under 9 atmospheres pressure of nitrogen.

The new technology is characterized by achievement of an increase in both strength and toughness by carefully controlling grain growth during the sintering stage, an essential characteristic of SiN.

Whiskers have been added in the past to improve fracture toughness. However, so much had to be added that it required pressurized forming and strength deteriorated as well.

The newly developed technology, on the other hand, maintained control of the shape and direction of the particles in its structure, giving it excellent functional properties.

National Lab Develops Test Equipment for Mechanical Properties

95P60111C Tokyo KAGAKU KOGYO NIPPO in Japanese 6 Feb 95 p 8

[FBIS Translated Text]

Diamond Thin Films and Whiskers To Be Tested

The National Research Laboratory of Metrology of the Agency of Industrial Science and Technology (AIST) (Tsukuba, Ibaraki Prefecture) has developed testing equipment which can inspect various mechanical properties of the diamond thin films used to coat cutting tools and the whiskers used as reinforcing material for composites. The ability of the test equipment to check hardness and elasticity has already been confirmed. Use of the new test equipment is expected to improve the reliability of thin films and reinforcing materials.

Diamond thin films and whiskers are being widely applied in many fields because they greatly improve the structural and functional properties of materials. However, these materials have proven too thin to be measured through available methods and with existing test equipment. The hardness of diamond thin film depends on the conditions under which methane density is controlled during the film's formation. However, there is virtually no data available on the relationship between the two. Therefore, the search for a suitable measuring device to improve reliability has been on for some time.

The lab is discovering various mechanical properties using the newly developed equipment. For example, the thinner the methane density and the slower the diamond thin films are formed, the closer the hardness and elasticity of the film approaches the hardness and elasticity of bulk diamond.

The whiskers were made of silicon carbide with an average hardness indicated at 2,100 Vickers.

National Lab Develops High Strength Ceramic Composites

95P60111D Tokyo NIKKAN KOGYO SHIMBUN in Japanese 22 Feb 95 p 8

[FBIS Translated Text]

530 Megapascal Bending Strength

The Agency of Industrial Science and Technology's (AIST) National Industrial Research Institute of Kyushu (Director, Kazuhiko Jin'nai) has developed a high strength fiber reinforced silicon carbide composite material with 55 percent fiber content and 530 megapascal bending strength. It has a density of 1.85 grams per cubic centimeter and 20 percent porosity. Since the fabrication method is also simple, the new ceramic composites are expected to be used for industrial materials including aerospace equipment and mill rollers.

Fiber-reinforced silicon carbide composite materials are fabricated through the vapor phase method, the organic silicon polymer method, or the hot press method. Creation of materials of the desired strength requires spending long periods at fabrication or impregnation with repeated sintering or heat treatment at extremely high temperatures. All of these methods are considered disadvantageous.

The Kyushu Institute has developed a sintering method that employs the reaction of silicon with resin and overcomes all of the above disadvantages while achieving a high level of strength. Specifically, silicon powders of below 5 micron in grain diameter and phenol resin were first made into carbon. Then polysilastyrene in an amount equal to that of the silicon was mixed in. Next, solvent was added to form a slurry. The slurry was mixed in a ball mill for three days.

A prepreg was made from this slurry substance and carbon fibers. This was dried and put in a mold. Then it was heat treated at a relatively low temperature of 1,450°C for 1 hour to produce a high strength fiber reinforced silicon carbide composites of 530 megapascal bending strength. The Kyushu Institute explained that the high strength was achieved in spite of low density "as a result of the smaller space between fibers by using micro fine silicon powders." Since the porosity rate was 20 percent, "it is possible to improve the strength further if the silicon powders were made even finer." Therefore further tests will be conducted. The above technology is scheduled to be presented at the "International Conference for High Temperature Ceramic Matrix Composite Materials" to be held in the U.S. 21-24 August 1995.

Hypersonic CFD Analysis for Aerothermodynamic Design of HOPE

43070025A Tokyo 32ND AIRCRAFT SYMPOSIUM in English 5 Oct 94 pp 339-342

[Article by Yukimitsu Yamamoto, head, Hypervelocity Aerodynamic Laboratory, Aerodynamics Division, National Aerospace Laboratory; Yasuhiro Wada, senior researcher, Computational Sciences Division, National Aerospace Laboratory; and Minako Yoshioka, system engineer, Fujitsu Ltd.]

[FBIS Transcribed Text]

Abstract

Numerical study of hypersonic flow around HOPE (H-II Orbiting Plane) is performed, using upwind TVD Navier-Stokes CFD code. Parametric computations are made to investigate the aero and aerothermodynamic characteristics of HOPE. In our calculations, NWT (numerical wind tunnel) at NAL (National Aerospace Laboratory) is used. NWT is the parallel vector supercomputer system, which enlarges the applicability and data productivity of CFD in practical aerodynamic design. Numerical results are compared with the experimental data obtained at Calspan's shock tunnel.

Introduction

With the increase of our computational ability, computational fluid dyanmics (CFD) becomes an important tool for the design of hypersonic vehicles. Through many comparisons with the experimental data, it has become clear that CFD now has the accuracy and reliability in analyzing hypersonic flow phenomena and can give detailed information of complex flows, such as three-dimensional separations due to compression surfaces and shock-shock interactions, etc. Moreover, aerodynamic heating which greatly influences the aerodynamic design and TPS requirements of hypersonic vehicles, can also be predicted with great accuracy. The need to support aerodynamic design has driven the use of CVD. However, for these design purposes, there is a problem in data productivity. From the design point of view, a great number of parametric studies are needed to determine the optimum configuration of hypersonic vehicles and current supercomputers are not powerful enough to perform those parametric calculations.

To resolve these problems, NWT (numerical wind tunnel) at NAL plays an important role. NWT, introduced at NAL in 1993, is a parallel vector supercomputer having 140 processing elements (PEs). Each PE has 1.7 GFLOPS peak performance and 256 MB main memory. This new computational environment changes significantly the applicability and utility of CVD for aerodynamic design. We introduce here numerical calculations of the flow around HOPE (H-II Orbiting plane)[1] using this new parallel machine. Computations were made by the flux-split TVD Navier-Stokes code[2] at the flow conditions of Calspan's shock tunnel (M_∞ = 12.0 to 19.0, α = 30, 35, 40 deg, Re_∞ = 3.15 x 10^4 to 1.88 x 10^6) and two typical re-entry flight conditions. In flight conditions, parametric configuration studies are made and the effects of angles of attack (α), side slip angle (β) are investigated. Also, real gas effects are analyzed by using chemically nonequilibrium flux difference-splitting code[3] and the decrease of aerothermodynamic heating on the HOPE TPS surface is estimated. In the present study, a total of 80 flow cases were computed.

HOPE Geometry and Grid

HOPE geometry and typical computational mesh used for the comparison of Calspan's shock tunnel experiments are shown in Figure 1. Present HOPE has tip fin controllers attached to the wing. Its total length is 16.5m from the nose to the fuselage base. Three-dimensional basic grids around this configuration are generated by using hyperbolic partial differential equations. Then, computational mesh is constructed, depending on the angles of attack and Mach numbers, because the outer inflow boundary adjusted to the bow shockwave in order to use the grid points efficiently. The clustering of grid point near the body surface is also made to resolve viscous effects. Cell Reynolds number is maintained about 2.0. In the final computational mesh of the basic symmetrical flow case, 91 points are distributed streamwise along the body, 93 points circumferential and 60 points between the body and outside of the bow shockwave. For the side slip flow case, the number of mesh points is doubled. Figures 2 and 3 show HOPE configurations calculated parametrically for the aerothermodynamic configurations design. Model 1000 series are double delta wing type geometry and model 2000 series represent power delta one. For each series of configurations, slight modifications were made and its effects on aerothermodynamic heating are investigated in detail.

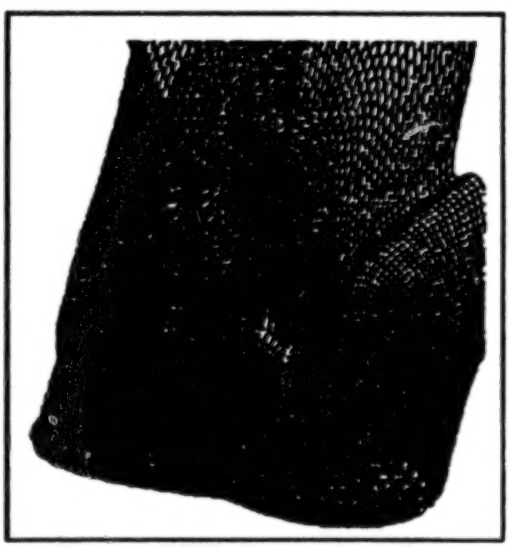

Figure 1. HOPE Computational Grids

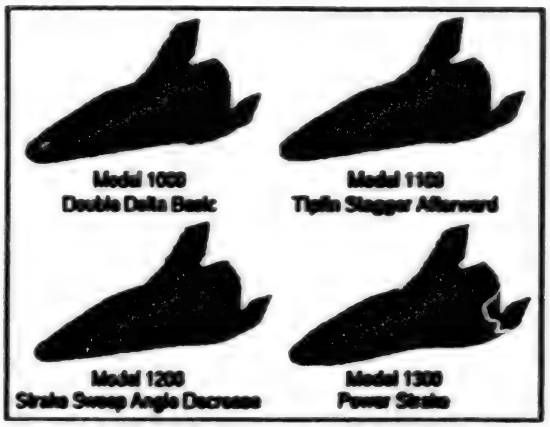

Figure 2. HOPE Geometry (Model 1000 Series)

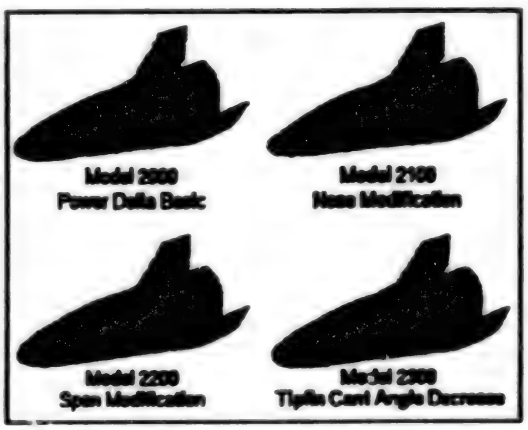

Figure 3. HOPE Geometry (Model 2000 Series)

Numerical Method

Basic equations used in the present analysis are Navier-Stokes equations with thin-layer assumption. The differencing used for perfect gas flow calculation is the upwind TVD flux-split method[2] and real gas computations were made by the flux-difference splitting method using a seven-species chemically non-equilibrium model.[3] A detailed description of the numerical algorithm is presented in Reference 2 and Reference 3, respectively.

Parallel Algorithm

The NWT (numerical wind tunnel) system at NAL is used in our parametric calculations for the aerodynamic design of HOPE. NWT is the parallel vector supercomputer having 140 processing elements (PEs). In the present parallel computations, a simple parallel algorithm has been developed; i.e., the computational regions are equally divided into 6-12 zones circumferentially and parallel computations using 6-12 PEs are performed for each computational flow region. In the present numerical analysis, 10 parametric parallel processes can be performed simultaneously. This means that 10 cases of the different flow conditions are computed in each computational cycle and a total of 60-80 PEs of NWT system are used at the same time.

Computational speed using six PEs are five times faster than that of one PE calculation. A 50- to 100-fold improvement in computational speed has been attained in the present numerical analysis. Multiple parallel processing now enables us to perform several hundred numerical computations and to produce sufficient numerical data for hypersonic aerodynamic design.

Numerical Results

Computations were made at the flow conditions of the Calspan's shock tunnel and two re-entry flight conditions. Freestream values of flight conditions are listed in Table 1. Real gas calculations were made at these flight conditions for the basic model 1000 and model 2000 geometry. Figure 4 shows the example of the comparisons of heat transfer distribution between numerical results and Calspan's shock tunnel data. Numerical results represent maximum heat transfer plots of each cross-sectional plane and experimental results present the wing leading edge heat transfer distributions at the constant chordwise location, where maximum heat transfer may be caused. Excellent quantitative agreements are obtained except for the wing root area. For the other nine flow cases, similar excellent agreements are obtained. Variations of the present flux-split CFD code were made through the comparisons of Calspan's shock tunnel data and it may be indicated that our CFD code can be used for the aerothermodynamic design of HOPE basic configurations. In the present study, our validated CFD codes are further applied for more improved aerothermodynamic configuration design. Then, parametric calculations for model 1000 and model 2000 series geometries are made at two flight conditions of Table 1. Angles of attack were taken α = 30, 35 and 40° for the basic model 1000 and model 2000 geometry. For the other models, the angle of attack is fixed to 35°. For all the numerical test cases, the effect of side slip angle (β = 5°) is also investigated. In a series of parametric computations, it must be denoted that a slight change of wing sweep angle and tip fin controllers has a great influence on heat transfer distributions of double delta type models (model 1000 series), whereas no significant effects are observed for the power delta type models (model 2000 series). Detailed results will be presented at the symposium site.

Table 1

Flow condition A	Altitude 80km
	M_∞ = 26
	U_∞ = 7346m/s
	T_∞ = 198.6K
	P_∞ = 1.053Pa
	Twall = 1200K
	Re_∞ = 1.409 x 10^5
Flow condition B	Altitude 65km
	M_∞ = 17
	U_∞ = 5205.3m/s
	T_∞ = 233.3K
	P_∞ = 10.93Pa
	Twall = 1200K
	Re_∞ = 8.059 x 10_5

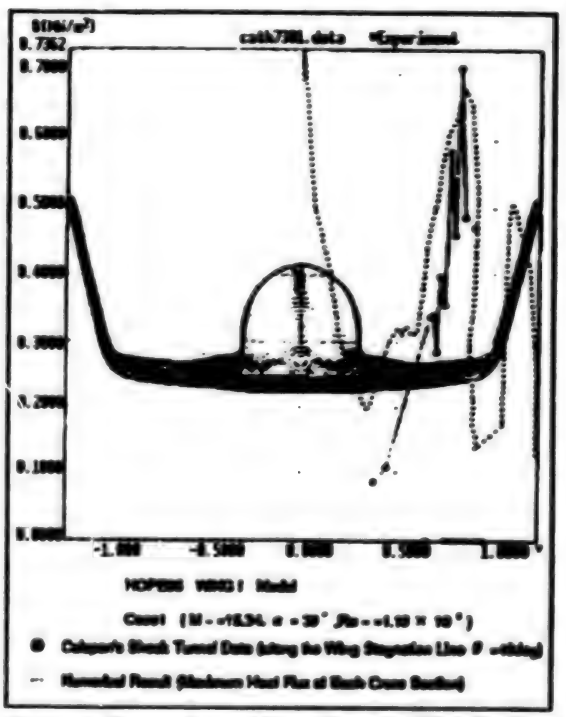

Figure 4. Comparison of Heat Transfer Distributions Near the Wing Leading Edge

Real gas effects at high Mach numbers are investigated by non-equilibrium flow calculations. In Figure 5, the comparison of maximum heat transfer distributions between the perfect and real gas computations are shown at the two flight conditions for Model 1000 geometry. Constant wall temperature of 1200K and noncatalytic wall condition are assumed. In the high Mach numbers (M_∞ = 26) and altitude (80km) case, local peak heating on the nose, wing and tip fin leading edges are simultaneously decreased for the real gas flow results. However, low Mach number (M_∞ = 17) and altitude (65km) case, local peak heating on the wing leading edge has almost the same between the two codes. This may be caused due to the difference of free stream density and velocity of each altitude.

Conclusions

In summary, we conclude:

1) For aerothermodynamic heating, the present flux-split Navier-Stokes CFD code gives excellent quantitative agreements with Calspan's shock tunnel data and it is indicated that CFD can be used as the reliable tool for the aerothermodynamic design of HOPE.

2) Parallel computations using NWT system at NAL can now produce as many numerical results as the current HWT can do, and CFD becomes a highly efficient tool for the design of HOPE geometries.

3) Through a series of parametric calculations by NWT, it is shown that a slight change of configuration has a considerable effect on aerothermodynamic peak heating for double delta type HOPE configurations.

4) In order to simulate the actual re-entry flight conditions of HOPE, chemically non-equilibrium flux difference splitting code has been applied, using seven species, one temperature model. Real gas effects appear in decreasing aerothermodynamic peak heating on the nose, wing and tip fin leading edges. However, these effects depend on the flight velocity, altitude, and wall catalicity. Therefore, more careful and precise analysis are needed through the considerable number of validation processes of the real gas CFD code.

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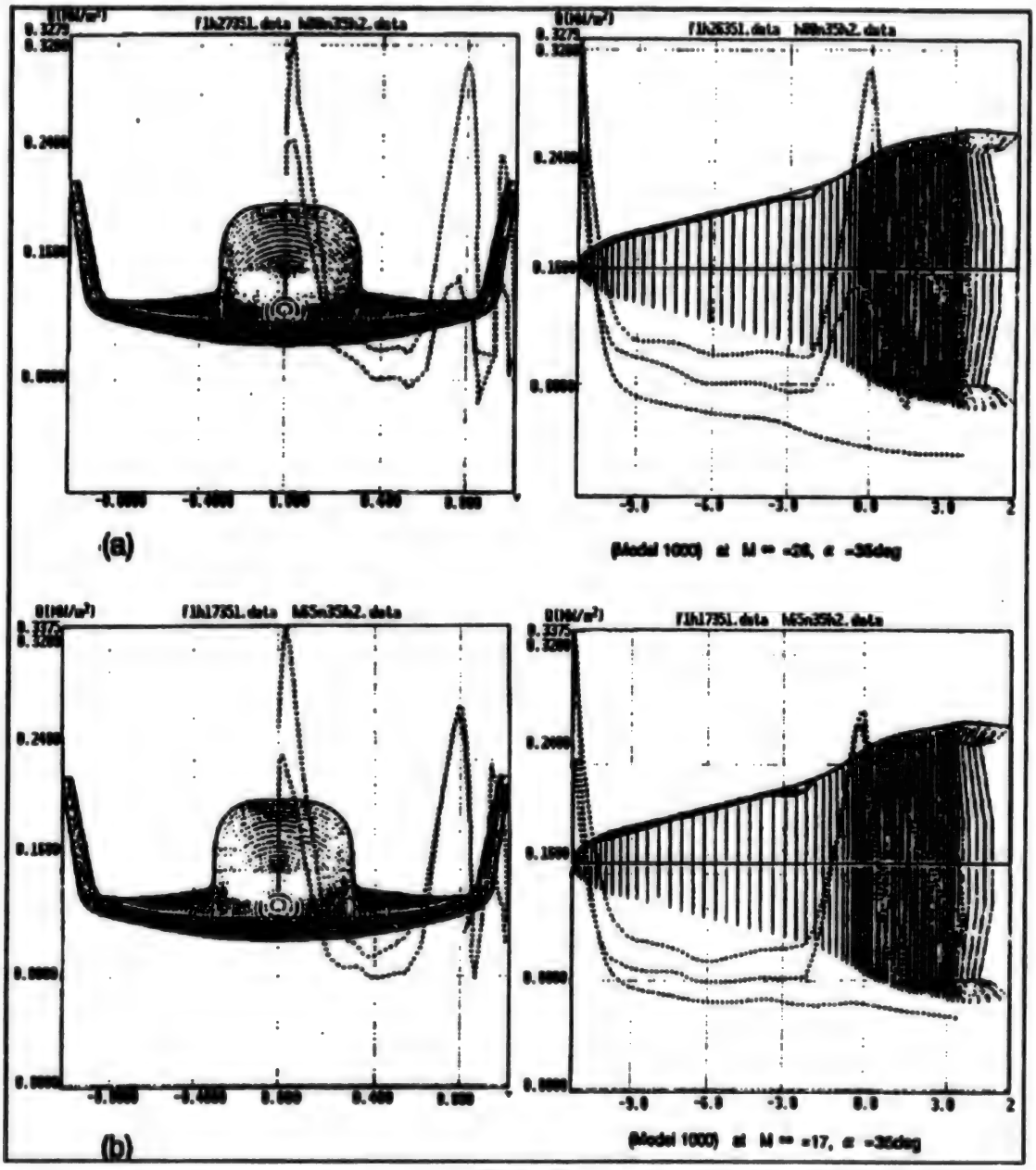

Figure 5.
Real and Perfect Gas Comparison of Maximum Heat Transfer Distribution of Each Cross Section of HOPE

NAL Conducts Successful Ramjet Engine Wind Tunnel Test

95P60112A Tokyo NIKKEI SANGYO SHIMBUN in Japanese 27 Jan 95 p 5

[FBIS Translated Text]

A Step Closer to Commercial Supersonic Transport

The National Aerospace Laboratory (NAL) of the Science and Technology Agency (STA) announced on 26 January that NAL has successfully conducted a wind tunnel test of a compact model ramjet engine which will be used in supersonic transport aircraft (SST). SST is under development with commercialization expected early in the 21st century. The model is still in an early stage without the engine burner. But the test confirmed that each component, including the air intake opening, operated normally in an air current moving at Mach 5.6. It is one step closer to development of supersonic transport aircraft for commercial purposes.

The compact model used for the wind tunnel test is a metal cylinder measuring 20 centimeters in height, 20 centimeters in width, and 2 meters in length. This model was placed in the supersonic wind tunnel in which a low pressure environment equivalent to 2,800 meters in altitude was created. Then an air current moving at Mach 5.6 was applied. As a result, the strength and durability of the model engine were confirmed to be adequate and the components, including the air intake opening and measuring device, operated smoothly as scheduled. Now NAL will promote design and production work for a combustor and a control device based on the test data.

A ramjet engine is capable of flying at supersonic speeds of Mach 3-5. It uses the incoming supersonic speed air directly for combustion, thus simplifying the structure without the need for a turbine or other air compression devices.

However, ramjet engines do not function at speeds lower than Mach 3. So they have to be used with ordinary jet engines, the combination of which is called a "combined cycle engine." The latest test data also is said to be useful for the design phase of development of the combined cycle engine in the future.

The Agency of Industrial Science and Technology of the Ministry of International Trade and Industry (MITI) since 1991 has been pursuing the super-hyper-sonic transport project (HST/SST Project) which will use ramjet engines. The project is expected to commercialize the HST/SST between 2020 and 2030 with a three-hour link between Tokyo and New York.

Fuji Heavy To Test Space Equipment in Russian Wind Tunnel

95P60112B Tokyo NIHON KEIZAI SHIMBUN in Japanese 20 Feb 95 p 11

[FBIS Translated Text]

Under Contract From NASDA

Fuji Heavy Industries Ltd. and Sumitomo Corporation were granted a contract by the National Space Development Agency (NASDA) to test space equipment using a Russian wind tunnel. It is in line with the Japan-Russia Space Cooperation Agreement signed in October 1993. It will be the first government level space-related experiment using the Russian facility. The experiments will begin in June with payment to the Russians of a little less than ¥20 million in fees.

A large wind tunnel approximately 1 meter in diameter located near Moscow at the Tzagi Aerodynamic Research Center in Zhikovsky will be used for a total of 13 tests at a maximum of Mach 18. The experiments are part of the R&D for the unmanned space shuttle "HOPE." The tests are to confirm performance of the wind tunnel with a simple model made from a combination of a ball and a cylinder.

FHI will conduct the experiments under contract with NASDA and Sumitomo Corp. will help prepare for the tests at the Center. FHI will analyze the test results and present a report in September.

If data analysis shows that the wind tunnel performance requirement have been met, further tests using a model in the shape of the HOPE are possible.

Japan does not yet have a large wind tunnel capable of tests at above Mach 10. On the other hand, Russia owns various high-tech testing facilities that they inherited from the former Soviet Union.

NAL To Construct High Temperature Shock Wind Tunnel

95P60112C Tokyo NIKKEI SANGYO SHIMBUN in Japanese 20 Feb 95 p 5

[FBIS Translated Text]

To Recreate Atmosphere Re-Entry Conditions

The Science and Technology Agency's National Aerospace Laboratory (NAL) will start constructing a high temperature shock wind tunnel which simulates air currents at ultra high temperature and high pressure in FY95. The reaction of the airship's surface during reentry from space into the earth's atmosphere will be recreated to obtain the data required to design space plane airframes and the "HOPE" minishuttle which Japan has been trying to develop. The construction is scheduled to take place at Kakuda Propulsion Center, NAL (Kakuda, Miyagi Prefecture), at a total cost of about ¥2 billion. The target year for completion is 1998.

The high temperature wind tunnel is cylindrical, measuring about 80 meters in length. It consists of a compressor tube, a shockwave tube, and a measurement section, as well as a barrier in between. The helium in the compressor tube is compressed by a high speed piston. When the helium reaches a certain level of pressure, it breaks through the barrier and pushes air out to the shockwave tube. The shockwave generated as a result goes forward to the second barrier and bounces back. The forward and backward shockwaves interfere with each other creating high temperature and high pressure shockwaves. These shockwaves then break through the second barrier and blow into the measurement section of the wind tunnel.

Through this method, the equipment can generate air currents up to 4500-10,000°C and of 1,500 atmospheres of pressure for 1/5 million second. The U.S. and Germany have similar facilities, but NAL's new equipment will have the highest performance.

Airframe models and parts will be placed in the wind tunnel. The blast of high temperature and high pressure wind will simulate atmosphere re-entry, allowing forecast of conditions during actual re-entry. In addition to obtaining computer-generated data necessary for

designing airframes and engines, the facility will allow the researchers to actually examine the high temperature and high pressure air current around the airframe.

MITI To Evaluate Rescue Airship Applications for Disaster Areas

95P60112D Tokyo NIKKAN KOGYO SHIMBUN in Japanese 20 Feb 95 p 1

[FBIS Translated Text]

Useful for Emergency Communications, Fire Extinguishing, Delivery

The Agency of Industrial Science and Technology's (AIST) Mechanical Engineering Laboratory (MEL) of the Ministry of International Trade and Industry (MITI) is planning to develop an emergency airship to respond quickly to large-scale disasters. In line with the plan, MEL will conduct evaluation tests in FY95 on three kinds of airships for communications/observation, fire extinguishing, and rescue goods delivery. Airships require no airports and cost less than satellites, thus raising expectations for their usefulness in disasters during which information transmission is extremely important. The Great Hanshin Earthquake provided many lessons as a result of the shutdown of ground communication circuits, the delay of fire extinguishing activities, and problems delivering emergency goods. As a result, "new weapons" are needed including airships as well as fire boat seaplanes to cope with disasters.

MEL intends to monitor and observe the earth's environment by flying a 200-meter long giant airship in the stratosphere at an altitude of 20,000 meters for a long period of time. Meanwhile, for three years MEL has been conducting experiments on a small demonstration model airship 20 meters long. The airship was said to be very useful for protection of wild animals, observation and protection of tropical forests, prediction of typhoon and large-scale flooding, radio relay during large scale disasters, and monitoring of large areas and traffic control.

The recent Great Hanshin Earthquake practically destroyed communications and traffic/transportation networks, hampering efforts to respond to the many fires. Therefore, the MEL decided to conduct new experiments on airships specifically to deal with great disasters.

Specifically, there are three kinds of experimental airships. Manned or unmanned airship for communications and observation will be used in place of destroyed communication facilities on the ground and to conduct communication relays by being positioned above disaster sites 24 hours a day.

Also evaluation tests will be conducted on optical cameras, infrared cameras, and synthetic aperture radar (SAR) aboard the airship to transmit images of disaster sites to the ground command center. "The airship is equipped with a high resolution device which can also catch movements of people at night," said Measurement Control Laboratory Chief Masahiko Onda of the Physical Information Department.

The fire airship initially will calculate the minimum amount of fire extinguishing material required. The AIST's Second Center will be remodeled to create a base for the airship, where a prototype radiator that can spray fire extinguishing material effectively inside buildings will be produced and evaluated.

The emergency goods delivery airship will be fire resistant, highly maneuverable, unmanned, and small (loading capacity of under 70 kilograms). The high performance delivery prototype airship and its supporting facility will be evaluated for operability using the global positioning system (GPS). It will provide emergency shuttle services to deliver medicine and water to central locations in disaster areas. When not used for rescue purposes, it will be used for nationwide express shipments between home delivery depots.

Sealed-Type Batteries for Electric Vehicles

95FE0144A Tokyo NATIONAL TECHNICAL REPORT in Japanese Vol 40 No 4, Aug 94 pp 59-67

[Article by Munehisa Ikoma, Nobuyasu Morishita, Yasuko Hoshina, Shinji Hamada, Naoto Hoshihara, and Koichi Yamasaka, EV Battery Development Center, Matsushita Battery Industrial Co., Ltd.; and Hiromu Matsuda, Kazuhiro Ohta, and Tadao Kimura, Home Appliance Technology Research Laboratory]

[FBIS Translated Text]

Abstract

As the batteries that possess the basic characteristics needed for electric vehicles to operate on urban streets—with sufficient energy density, power density and cycle life—Matsushita Batteries Industrial is developing sealed lead acid battery and nickel-metal hydride battery with a goal of their practical use by 1998.

To make nickel-metal hydride batteries large, we have developed a nickel anode, which has an excellent high-temperature charging efficiency, by adding a calcium compound. Also, we have succeeded in developing a cathode made of hydrogen-absorbing alloy which has a high capacity and a long cycle life by optimizing the alloy composition, surface treatment, binders, and conductive additives. The module battery with these features has twice the energy density of a lead-acid battery, a high power density (160 Wh/kg) and a long cycle life.

For the lead-acid battery, we have developed an anode with a high capacity and a long cycle life by increasing the PbO_2 density and adding $SnSO_4$. We also optimized the amount of lignin and $BaSO_4$ additives to develop a cathode with no deterioration in its high-rate discharging characteristics, even after repeated charge-discharge cycles. The [lead-acid] module battery with these features has a far better cycle life (500 cycles) and a high power density compared to a conventional lead-acid battery.

With these improvements in basic performance, it is clear that these two types of batteries can be used on electric vehicles.

1. Introduction

The destruction of the global environment, such as the acid rain due to nitrogen oxides and global warming by carbon dioxide, has become a serious issue, and electric vehicles [EVs] with no exhaust gas are gaining its popularity as a solution to the global problem. After the United States government adopted the Clean Air Act (June 1990), California mandated automobile manufacturers to manufacture and sell EVs with no emission starting in 1998. Thirteen more states are likely to follow California's mandate. In Japan, the Ministry of International Trade and Industry [MITI] has adopted a plan to have 200,000 EVs operating by 2000. Domestic and foreign automobile manufacturers are seriously engaged in the development of full-scale EVs that can operate in urban streets for practical tasks by 1998.

The existing EVs not only have shorter cruising ranges per battery charge compared to conventional cars equipped with [internal combustion] engines, but the EVs also have poor acceleration and hill climbing capability, and are cumbersome to maintain, such as adding water and charging [batteries]. Moreover, the EVs are more expensive, and they are not popular at all. These problems arise mostly from the batteries on EVs, and hence it is critical not only to improve the performance of existing batteries but also to develop new types of batteries with high energy densities.

Battery manufacturers and research laboratories around the world are engaged in R&D of existing batteries, such as the lead-acid battery and the nickel-cadmium battery, as well as new types of batteries, such as the nickel-metal hydride battery, the sodium-sulfur battery and the lithium battery. In the United States, in particular, automobile manufacturers joined the government and electric utilities in establishing the USABC [U.S. Advanced Battery Consortium], which began to develop the new types of batteries mentioned above starting in May 1992. Batteries for EVs require improved basic battery characteristics, such as energy density, power density and cycle life, to operate EVs on urban streets. It is important that such batteries should have a capacity of 50-120 Ah [amperes-hour], a total voltage of 200-300V, be maintenance free because many batteries are needed, and the reliability and safety of the batteries must be established. Also, charging systems and monitoring systems for such batteries must be developed.

With the goal of practical applications in the 1990s, the authors are conducting R&D on sealed lead-acid batteries and nickel-metal hydride batteries, which are considered to have well-balanced overall performance characteristics described above. We report here lead-acid batteries and nickel-metal hydride batteries whose basic performance we have improved so that they can be used on EVs.

2. Nickel-Metal Hydride Battery for EVs

2.1. Summary of Nickel-Metal Hydride Battery for EVs

Nickel-metal hydride battery uses nickel oxide for the anode, similar to the nickel-cadmium battery, and the hydrogen absorbed into a hydrogen-absorbing alloy for the cathode. This is a new battery system with a high energy density, which was put to practical use[1] as a power supply for portable devices. This battery system has many superior characteristics and is expected to serve as a relatively large portable power supply.

This battery has the following five advantages to be used with EVs:

(1) The battery can attain a high energy density (the cruising range per battery charge is long).

(2) The battery has a high power density, and hence provides a stable power output even when it is deeply discharged (better acceleration and hill climbing capabilities are attained).

(3) The battery's cycle life is superior.

(4) The battery is maintenance free and very safe.

(5) The battery is environmentally acceptable and can be recycled.

Because of these advantages, this is the type of battery many public research laboratories and battery manufacturers are rushing into its R&D.

The charging and discharging reactions of the electrodes in an alkali electrolyte are given by Equations (1) and (2):

Anode:

$$Ni(OH)_2 + OH^- \rightleftharpoons NiOOH + H_2O + e^- \quad (1)$$

Cathode:

$$M + H_2O + e^- \rightleftharpoons MH_{ab} + OH^- \quad (2)$$

Here, M is the hydrogen-absorbing alloy while MH_{ab} represents the absorbed hydrogen (metal hydride). The reaction as a battery is summarized in the following equation:

$$Ni(OH)_2 + M \rightleftharpoons NiOOH + MH_{ab} \quad (3)$$

This model is illustrated in Figure 1. In a nickel-metal hydride battery, the hydrogen atom moves from the anode to the cathode during charging and in the reverse direction during discharging without any change in the electrolyte.

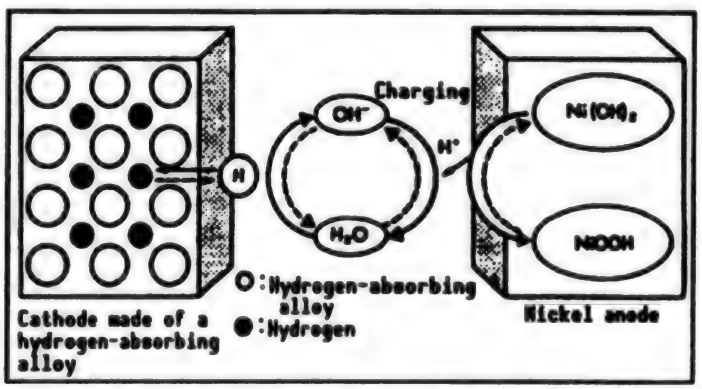

Figure 1. Charge-Discharge Mechanism of Nickel-Metal Hydride Battery

The battery can be sealed when the cathode capacity is made sufficiently larger than the anode capacity so that the oxygen generated at the anode when the battery is overcharged is reduced by the hydrogen in the cathode made of a hydrogen-absorbing alloy according to Equation (4):

$$MH_x + O_2 \rightleftharpoons MH_{x-4} + 2H_2O \quad (4)$$

Also, to suppress the generation of hydrogen gas from the cathode and accompanying rise in the internal pressure due to rapid charging or the [rising] temperature of the charging atmosphere, measures have been taken to make the cathode water repellent. With these measures, hydrogen gas can directly be absorbed from the solid-gas phase boundary on the surface of the hydrogen-absorbing alloy according to Equation (5), and thus suppress the rising of internal pressure[2]:

$$MH_x + H_2 \rightleftharpoons MH_{x+2} \quad (5)$$

The construction of a sample nickel-metal hydride battery is shown in Figure 2.

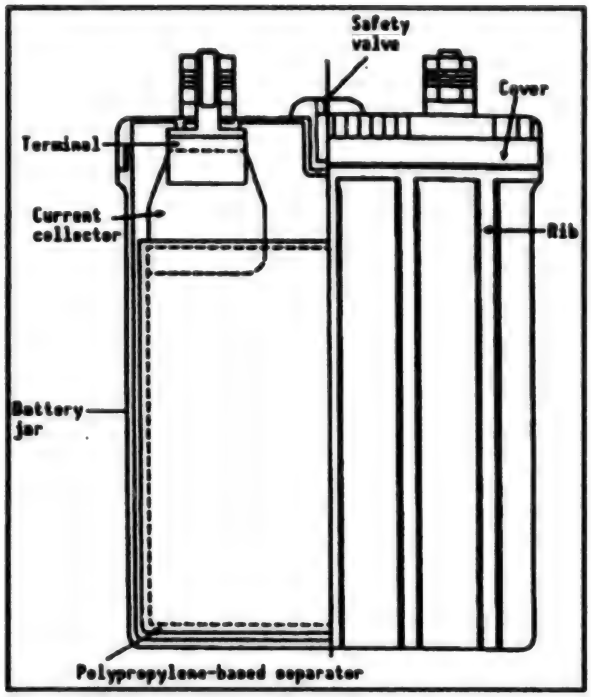

Figure 2. Construction of Nickel-Metal Hydride Battery for EVs

2.2. Component Technology of Nickel-Metal Hydride Battery for EVs

2.2.1. Development of Nickel Anode

A feature critical to the reliability in the cruising range per battery charge is to have a stable discharging capacity at a wide range of temperature for a battery used in an actual EV. In general, when the nickel anode reaches 45°C, the oxygen generating reaction given by Equation (6) begins to compete with the charging reaction described by Equation (1). As a result, the charging efficiency drops and the discharging capacity is reduced:

$$OH^- \rightarrow (1/2)H_2O + (1/4)O_2 + e^- \qquad (6)$$

This reaction takes place because the oxygen generating overvoltage of the nickel anode decreases as temperature rises. To prevent this decrease in the overvoltage, measures such as adding CdO to the anode have been considered. However, one of the features of this type of battery is not to contain any Cd, and hence CdO cannot be added. In addition, since EVs use large batteries, heat generated inside such batteries during charging dissipates slowly, and the temperature inside the battery is expected to rise compared to small batteries. Hence, it is necessary to raise the charging efficiency to a higher value than that obtained by adding CdO.

We have studied the utilization of nickel hydroxide at 45°C when various compounds were added to the nickel anode.[3] Our results are illustrated in Figure 3. It is clear from the figure that the addition of $Ca(OH)_2$, CaS, CaF_2, $Sr(OH)_2$ or Y_2O_3 is effective in using more than 70 percent of nickel hydroxide. In particular, the utilization rate reaches over 80 percent when $Ca(OH)_2$, CaS or CaF_2 is added, indicating that these compounds are better in their high temperature charging efficiency than that of CdO. The charging behavior when Ca compounds are added is illustrated in Figure 4. The voltage toward the end of the charging operation of a battery with a Ca compound or CdO additive increases compared to the voltage of a battery with no additives. Also, the rise in the battery temperature is less compared to a battery with no additives. These facts indicate that the utilization rate of nickel hydroxide is increased because adding Ca compounds to

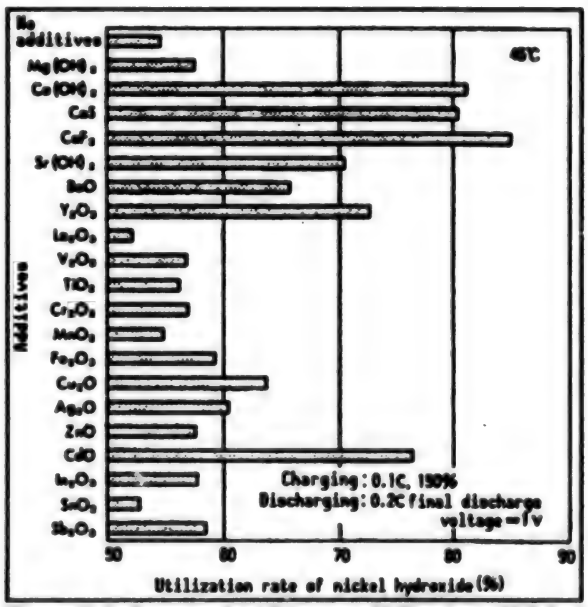

Figure 3. Influence of Additives on Utilization of Nickel Hydroxide

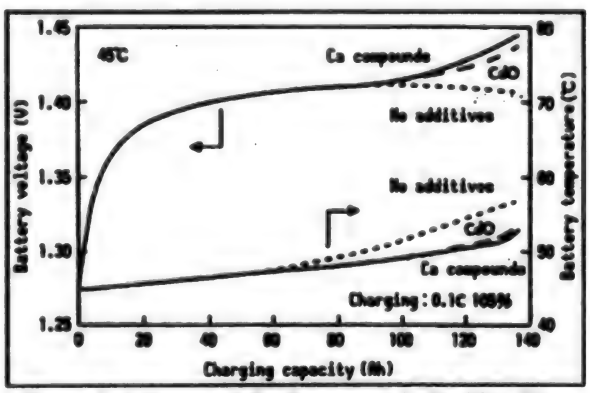

Figure 4. Influence of Ca Compound in Positive Electrode on Cell Voltage and Temperature Compared With CdO During Charge Process

the anode improves the oxygen generating overvoltage at 45°C and let the reaction in Equation (1) proceed to a highly charged level.

2.2.2. Development of Hydrogen-Absorbing Alloy Cathode

It is very important that the hydrogen-absorbing alloys to be used in EV batteries have high capacity, long life and be inexpensive. To meet these requirements, we have adopted $MmNi_5$-based, AB_5 alloys, which are used in nickel-metal hydride batteries for portable devices. The composition and characteristics of these alloys[1,4] are listed in Table 1. Some of the Ni in $MmNi_5$ was replaced by other metals (Mn, Al, Co) to reduce the equilibrium pressure without reducing the amount of hydrogen stored. With this measure, we succeeded in increasing the [battery] capacity (approximately 300 mAh/g [milli-ampere-hour/gram]). We were able to repeat over 1,000 charge-discharge cycles by modifying the alloy surface with alkali treatment and improving the durability with optimized replacement of Co.

Table 1. Characteristics of Hydrogen-Absorbing Alloys for Cathode

Composition	$MmNi_{5-x-y-z}\ Mn_xAl_yCo_z$ $0.2 \leq x \leq 0.4;\ 0.1 \leq y \leq 0.3;\ 0.5 \leq z \leq 0.75$
Plateau pressure	0.03-0.05 MPa (H/M = 0.5, 45°C)
Amount of absorbed hydrogen (PCT curve)	320-340 mAh/g (hydrogen equilibrium pressure = 0.5 MPa)
Discharging capacity	290-310 mAh/g
Cycle life	1,000 cycles

There is a possibility that the cycle life of an EV battery may deteriorate from the corrosion of the alloy used in the cathode plate due to nonuniform distribution of current as the plate becomes larger, or from the peeling of the alloy powder from the core material. The testing result on the cycle life of the cathode plate for an EV battery is compared in Figure 5 with that of a cathode made of a bubbling metal. We were able to develop a cathode plate that has a cycle life equivalent to or better than a bubbling metal cathode, which has a three-dimensional conducting frame, by optimizing binders and conducting additives.

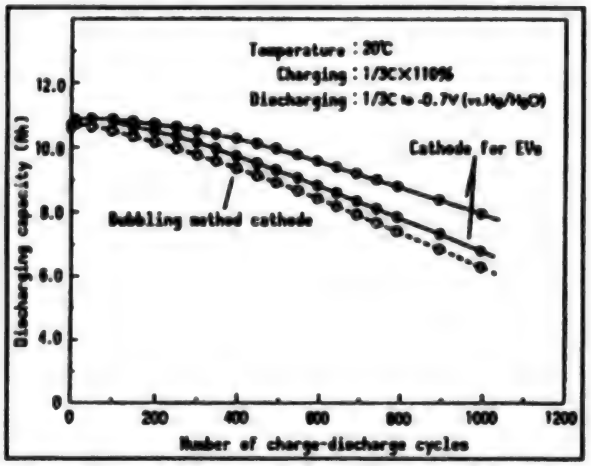

Figure 5. Cycle Characteristics of Negative Electrodes for EV-Batteries

2.3. Battery Characteristics

Based on the above component technologies, we have constructed a module battery (12V), and confirmed its basic characteristics for use in EVs.

2.3.1. Charging Characteristics

Since EV batteries are basically charged at night, our module battery was designed to charge at a constant current of 10-30 A until the internal pressure of the battery reached 0.15 MPa, considering the electric power available at ordinary homes. The charging characteristics of our module battery are shown in Figure 6. Heat is generated by the reaction in which the hydrogen-absorbing alloy forms a hydride and by the Joule's heat until the battery reached the overcharged state. The temperature rise, however, was limited to about 5°C even when a current of 30 A was used for charging. In the overcharge range, heat is generated by the reaction of the oxygen emitted from the anode and the hydrogen that existed at the cathode, but this reaction raised the battery temperature by approximately 8°C. The variations in the voltage, internal pressure and the temperature of each unit cell that make up the module battery were similar. From these results, we learned that it is possible to charge a large nickel-metal hydride battery for EV without markedly raising the temperature and the internal pressure of each unit cell by adopting appropriate controls for charging, as in the case of small batteries for portable devices.

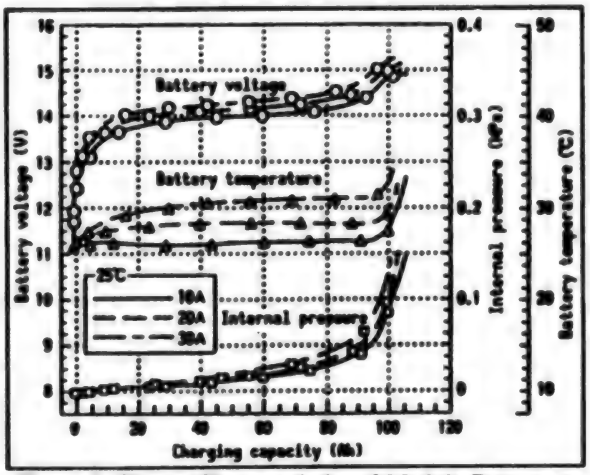

Figure 6. Charge Characteristics of Module Battery at Various Charge Currents

We present the charging characteristics of our module battery in a wide range of temperatures from -20 to 45°C in Figure 7. An improved module battery B indicated a stable discharging capacity in a wide range of temperatures. In a 45°C atmosphere, a module battery A, which used a conventional nickel anode with no Cd additives, exhibited a serious degradation of charging efficiency at 45°C because the overcharge from oxygen generation was too small. When compared to the data at 25°C, module battery A could manage a discharging capacity of about 50 percent [at 45°C]. On the other hand, module battery B, which had an anode with Ca compound additives, maintained at 45°C a discharging capacity which was 90 percent of that at 25°C.

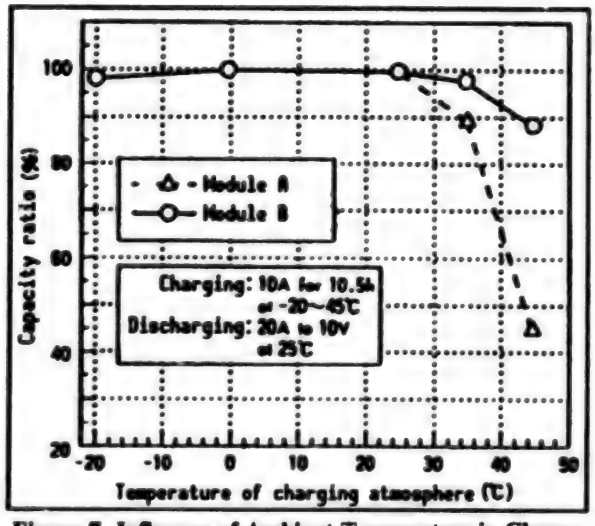

Figure 7. Influence of Ambient Temperature in Charge of Module Battery on Capacity Ratio (Module A: Conventional type; Module B: Improved type)

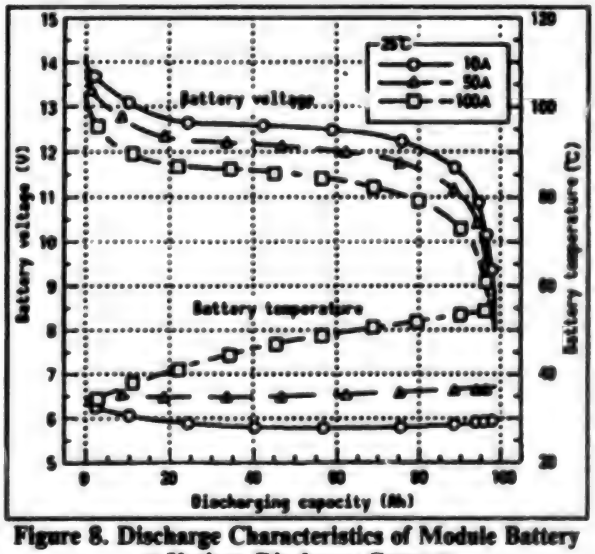

Figure 8. Discharge Characteristics of Module Battery at Various Discharge Currents

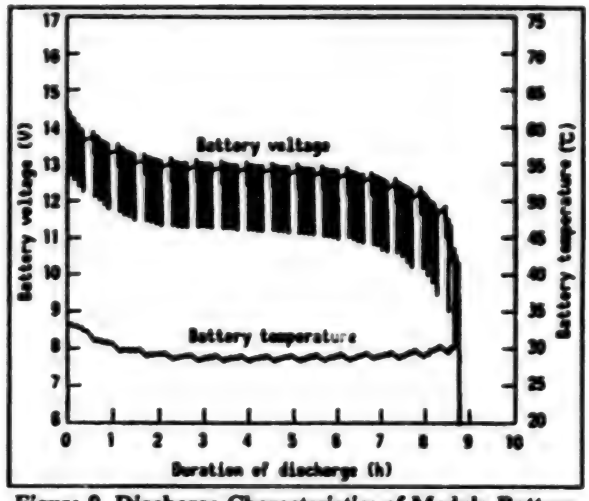

Figure 9. Discharge Characteristics of Module Battery at SFUDS79 model

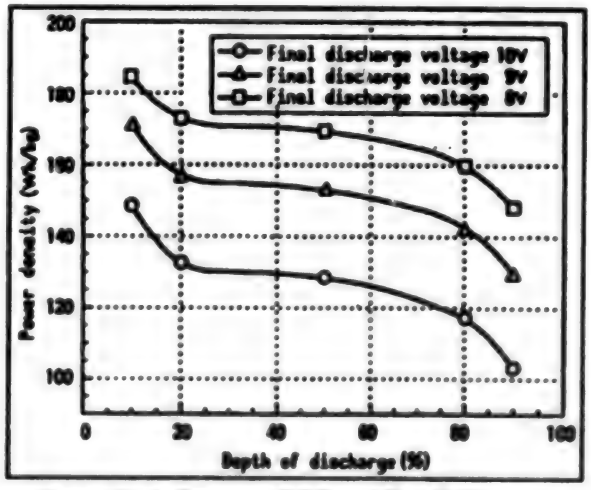

Figure 10. Influence of DOD and End Voltage on Specific Power for Pulse Discharge

2.3.2. Discharging Characteristics

Discharging characteristics of the module battery measured under various discharge conditions are shown in Figs. 8 through 10.

The result of continuous discharging at 20 A shown in Figure 8 indicates that the energy density of this battery is 70 Wh/kg. The discharging capacity for continuous discharging at 100 A is maintained at 95 percent or more of the capacity for continuous discharging at 20 A. During this discharging, the temperature rise inside the battery was about 25°C. The actual driving conditions consist of complicated combinations of acceleration, driving at constant speeds, and recovery charging; as a result discharging behavior similar to pulse discharging

emerges. Hence, it is unlikely that continuous discharging lasting for almost one hour, as described above, takes place [in practice]. The discharging characteristics corresponding to the discharging conditions of SFUDS79[5], which is closer to the actual driving pattern, are shown in Figure 9. The figure indicates that a stable voltage behavior is exhibited up to a depth of discharge of 80-90 percent, with almost no rise in the battery temperature. The relation between the power density and the depth of discharge under pulsed discharge conditions is shown in Figure 10. This figure indicates, as in the case of the SFUDS79 discharge pattern, that a stable power density is exhibited up to a depth of discharge of 80-90 percent. Also, the figure indicates that the lower the final discharge voltage, the higher power density becomes. With a final discharge voltage of 8V, an excellent power density of 160 Wh/kg or more was achieved even at a depth of discharge of 80 percent. The reason for the higher power density when the final discharge voltage is lower is likely that the anode polarizes more during discharge. From these results, it is clear that the module battery exhibits excellent power density up to a high value of the depth of discharge.

2.3.3. Cycle Life Characteristics

The cycle life characteristics of the module battery are shown in Figure 11. Stable characteristics without any deterioration in the discharging capacity or rise in the internal pressure after 500 cycles [of charging and discharging] are clearly demonstrated, indicating the possibility of a cycle life of 1,000 cycles. From this, we infer that the module battery will be useful for approximately 100,000 km of EV driving.

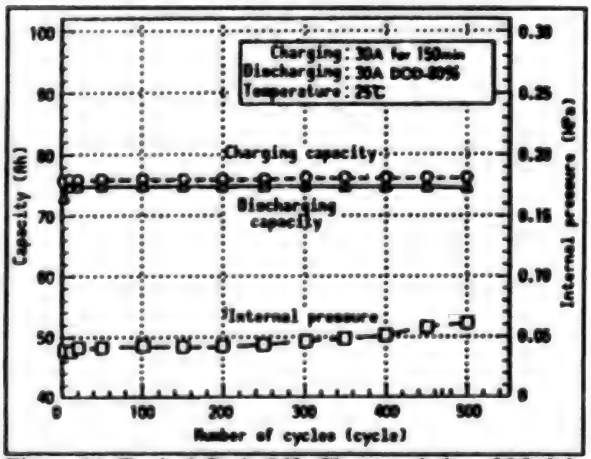

Figure 11. Typical Cycle Life Characteristics of Module Battery

3. Sealed Lead-Acid Battery for EVs

3.1. Summary of [Open] Lead-Acid Battery for EVs

This is the type of battery most commonly used in EVs currently being marketed. However, this type of battery has weak power characteristics and low cycle life when discharged at a high rate. Also, because it is an open type battery, there are problems in cumbersome maintenance and safety. With recent progress in technology, it is possible to achieve acceleration comparable to a gasoline-engine car, though it is still difficult to improve substantially on the cruising range per battery charge. By applying the sealing technology, one can eliminate the maintenance of adding water. If an EV with a practical driving range of 100 km can be developed with such a battery, then it is possible to make EVs popular in steps by selecting appropriate usage of such EVs.

The lead-acid battery has the following four advantages:

(1) High power density can be achieved (superior acceleration and hill-climbing capability).

(2) The battery has an excellent cycle life.

(3) The battery is maintenance free and very safe.

(4) The battery is relatively inexpensive, and can be recycled.

For these reasons, this is a battery system that many public research laboratories and battery manufacturers are accelerating its R&D.

3.2. Principles of Sealing

The lead-acid battery for EVs being developed by our company uses a "cathode absorption sealing" method, which eliminates the maintenance problem and is very safe. An unwoven cloth made of very fine glass fibers, called a retainer matt, is used as a separator. The electrolyte (dilute sulfuric acid) is kept inside this separator. During the charging operation, oxygen gas is generated from the anode through a competitive reaction described by Equation (7). The oxygen reaches the cathode surface after passing through the gaps in the fiber glass inside the retainer matt or through the outside of the terminal plates. The oxygen is then absorbed by the cathode through reactions described by Equations (8) and (9), thus enabling us to seal the battery.

$$\text{Anode: } H_2O \rightarrow (1/2)O_2 + 2H^2 + 2e^- \qquad (7)$$

$$\text{Cathode: } Pb + (1/2)O_2 \rightarrow PbO \qquad (8)$$

$$PbO + H_2SO_4 \rightarrow PbSO_{4_2}O \qquad (9)$$

In addition, to seal the battery, Pb-Sb alloys, which have low overvoltage for hydrogen generation, have been replaced by Pb-Ca-Sn alloys to be used in the anode and cathode collector lattices, to prevent the hydrogen generation during self-discharge and prevent the loss of water.

3.3. Component Technology of Lead-Acid Battery for EVs

3.3.1. Extending the Life of Active Materials for Anode

It is known[6] that a liquid-type, rechargeable lead battery has a finite life because of the changes in the porous

structure of the anode active material (PbO_2) due to repeated charging and discharging, the deterioration of bonding strength among PbO_2 granules and the peeling of PbO_2 powder. Similar phenomena are expected to occur as well in the case of a sealed lead-acid battery, thus reducing the battery capacity. Hence, we have studied the extension of the battery life by focusing on the active material density, which is considered to greatly affect the porous structure and reactivity of PbO_2.

The anode active material, PbO_2, is obtained by oxidizing a paste, which is a mixture of lead powder (PbO is its main ingredient; powder that contains 15-35 percent of Pb) and dilute sulfuric acid of a given concentration. In our study, the active material density was varied by controlling the fabricating conditions of the paste.

Three batches of anode active material, with low, medium and high apparent densities, were prepared and used to fabricate module batteries with the rated anode capacity. Then, cycle life tests were performed on these module batteries. The test results are presented in Figure 12. We found that the lower the active material density, the larger the peak capacity during the cycle testing and the higher the utilization rate of the active material, while the shorter the cycle life became. The batteries with the medium- and high-density active materials exhibited relatively small capacities initially, but they had longer cycle life compared to the battery with the low-density active material. Therefore, we conclude that medium- and high-density anode active materials, whose cycle life is longer than that of the conventional low-density active material with a higher utilization rate, are superior in extending the cycle life of batteries for EVs.

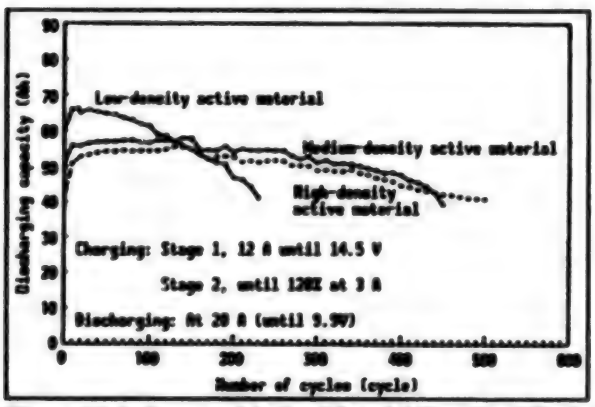

Figure 12. Influence of Active Material Density of Positive Electrode on Cycle Life

3.3.2. Improved High-Rate Discharging Characteristics of Anode

To improve the utilization rate of the anode during high-rate discharging, we have studied the effects of various additives. As a result, we found that $SnSO_4$ is an effective additive. As is shown in Figure 13, the discharging capacity at a rate of 2C of the anode active material with the $SnSO_4$ additive is improved by approximately 15 percent compared to the active material without the additive, thus clearly indicating an improved utilization rate at a high rate of discharge. The discharge voltage was also higher with the $SnSO_4$ additive, by about 0.12V per module.

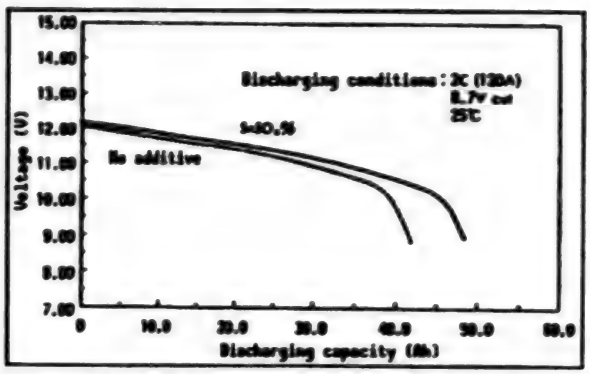

Figure 13. Effect of $SnSO_4$ Addition to Positive Electrode on Discharge Characteristics

We can understand that the active material particles become finer when $SnSO_4$ is added. This fact is also consistent with our finding that the specific surface area of the active material without the additive was 8.8 m^2/g, while that of the active material with the additive was 4.5 m^2. The improvements in the battery capacity, when it is discharged at a high rate, and its discharge voltage can be considered to have resulted from the increased reaction area due to the particles becoming finer and the decreased current density during discharge. These effects are maintained even when the battery is subject to repeated charge-discharge cycles.

Let us consider the phenomenon of $SnSO_4$ making the anode active material finer. According to Pourbaix's pH-potential diagram,[7] Sn is almost stable as SnO_2 in the ranges of PbO_2's charge-discharge potential (approximately 1.7-2.0V vs. NHE [expansion unknown]) and pH (approximately 1-6). Therefore, we infer that Sn in $SnSO_4$ is not dissolved in the electrolyte but exists in the anode active material in the form of SnO_2. Meanwhile, β-PbO_2 belongs to a tetragonal system, which is also the case for SnO_2, with the former's lattice constant very similar to that of the latter. Thus, SnO_2 can serve as the crystal core of the β-PbO_2 formed during charging. We infer that fine particles of SnO_2, which do not participate in chemical reactions, are uniformly dispersed in the anode active material, to which $SnSO_4$ is added. Moreover, we infer that the β-PbO_2 accumulated on this uniformly distributed SnO_2 also becomes fine particles.

3.3.3. Improved Cathode Cycle Life Characteristics

It is necessary for a battery for EVs to maintain a stable, high discharge rate from the beginning of its usage to the

end of the battery's life. In Figure 15, we compare the initial-stage discharge characteristics and those after 300 cycles at a discharge rate of three hours. In the initial stage, the [discharging] capacity is maintained at a discharge current of 20 A, but the capacity is significantly reduced as the discharge current is increased. This is an important issue related to the deterioration of an EV's performance when high power is needed, such as in high-speed driving or climbing hills.

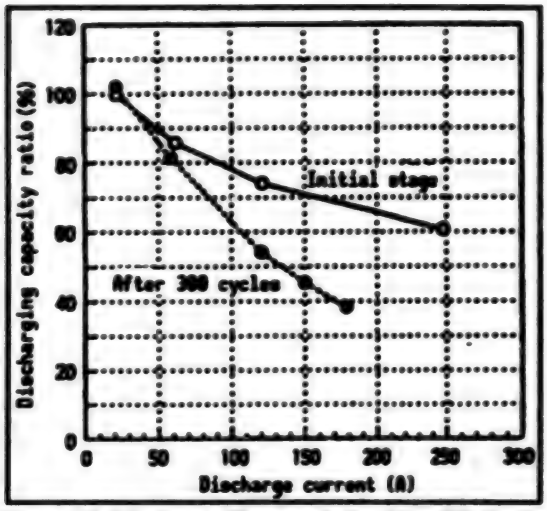

Figure 15. Discharge Characteristics After 300 Cycles Compared With Initial Stage

In Figure 16, we present the measured potential behavior of the anode and cathode of a cell, which is part of the module battery, when the cell is discharged at a current of 150 A, after the battery has been subjected to 300 [charge-discharge] cycles. One can see that the high-rate discharge performance of the cathode has severely deteriorated from the fact that the battery capacity is limited by the capacity of the cathode. The specific surface area of the cathode active material is 0.7 m^2/g in the initial stage, but it has decreased to 0.3 m^2/g after 300 cycles. We infer that the cause of deteriorating discharge performance is the decreasing reaction area of the cathode active material through repeated charge-discharge cycles. Hence, we have improved the following two items to increase the reaction area of the cathode active material and to reduce the current density.

(1) We optimized the cathode additive (lignin, $BaSO_4$, etc.), increased the specific surface area of the cathode active material, and increased the reaction area of the cathode.

(2) We increased the number of electrode plates by using thin plates, and thus increased the area of the electrode.

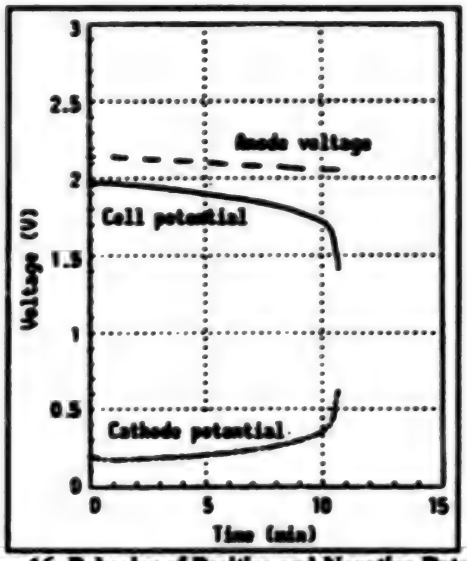

Figure 16. Behavior of Positive and Negative Potential at 150 A Discharge After 300 Cycles

With these improvements, we have developed a cathode plate whose high-rate discharge performance does not deteriorate even after repeated charge-discharge cycles.

3.4. Battery Characteristics

The module battery was constructed based on the above component technology, and we have confirmed its basic characteristics to be used on EVs.

3.4.1. Cycle Life Tests Under the SFUDS79 Conditions

The result of our cycle life tests performed under the SFUDS79 discharge conditions is shown in Figure 17. These tests were performed by using a pattern, which is a combination of high and low discharge rates to simulate the actual driving conditions. With this testing method, we can identify the variations in high-rate discharge performance by repeating charge-discharge cycles as stated above. We have confirmed that our module battery had excellent characteristics with a cycle life of 500 cycles, which was a great improvement from that for a conventional battery, by using a cathode, whose capacity deterioration due to repeated high-rate discharging was controlled, and an anode for which the density of PbO_2 had been increased.

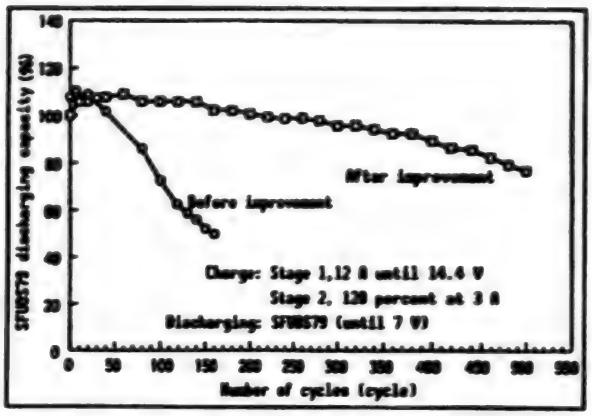

Figure 17. Typical Cycle Life in SFUDS79 Discharge Condition

3.4.2. Power Characteristics

The relation between the energy density and the power density (Ragone Plot) is shown in Figure 18. When compared to a conventional, sealed lead-acid battery (immobile type), the energy density at high power has greatly increased by improving the high-rate discharge characteristics of the anode active material, increasing the electrode area, and by optimizing the design conditions.

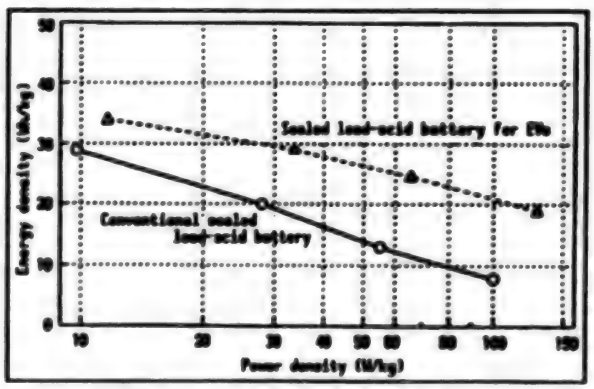

Figure 18. Relationship Between Specific Energy and Specific Power (Ragone plot)

4. Conclusion

In this article, we have reported the component technologies and characteristics of sealed nickel-metal hydride batteries and lead-acid batteries for EVs. These two types of batteries have superior characteristics in energy density, power density and cycle life, and hence it is clear that they are eminently suited for EVs.

As we are shouting about environmental issues and diversification of energy resources, we are expecting a great deal from EVs. It is not too much to say that the success of EVs depends on the successful development of these batteries. To make these batteries become "the heart of the automobile," it is necessary to improve the basic performance further, and to establish these batteries as the power supply system.

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NEC Develops Image Processing Equipment for Aircraft

Synthetic Aperture Radar Data To Be Processed On Board

95P60114A Tokyo NIKKEI SANGYO SHIMBUN in Japanese 16 Feb 95 p 1

[FBIS Translated Text] NEC Corporation has developed equipment able to process images in real time from data obtained through synthetic aperture radar (SAR), a kind of radiowave sensor. Traditionally, data entered the receiver aboard the aircraft and the processing into images took place on the ground. The ability to process images aboard the receiving aircraft makes likely expansion of the use of SAR, including rescue work at sea which requires immediate response. NEC expects to sell approximately 10 sets per year by taking orders mainly from government agencies such as the Maritime Safety Agency.

SAR is a radio sensor through which microwaves are irradiated from the sky. It can observe rolling hills and physical characteristics of the ground by evaluating the degrees of wave reflection at the receiving end. Unlike optical sensors, SAR is capable of conducting topographical observation and ocean search at night or on cloudy days. NEC, in April 1994, commercialized aircraft mountable SAR which consists of a receiver, a transmitter, and an antenna. But the data received was recorded on magnetic tape and processed into images back on the ground.

The new system can process the data received on board the aircraft in real time. It is capable of instantly processing an amount of data that it took a work station on the ground about four hours to process into images. For installation in small aircraft such as light planes, the SAR and the monitor can be placed in two boxes each measuring 69 centimeters in height, 45 centimeters in width, and 72 centimeters in depth. Overall volume was reduced to about one-third that of the processing equipment used on the ground.

When combined with the company's aircraft mountable SAR, options available for various purposes include 5-meter resolution for 5 kilometer-wide observation or 10-meter resolution for a 10-kilometer wide observation path. Also it is possible to calculate the latitude and longitude of a point in the picture through the global positioning system (GPS). The processing equipment is ¥ 140 million per set, and ¥ 350 million when combined with an aircraft mountable SAR.

The SAR has been used for satellites by the National Space Development Agency for resource probing. NEC's development of new processing equipment is expected to have applications for emergency-related operations such as rescue efforts at sea.

Sixteen Inch Wafer Project To Be Postponed Until FY96

95P60113A Tokyo NIKKAN KOGYO SHIMBUN in Japanese 3 Feb 95 p 7

[FBIS Translated Text] It is likely that the joint government-private sector "16 Inch Wafer Technology Joint Development Project" upon which the silicon crystal industry now is trying to focus, will be postponed until FY96. This is a mega project that has attracted considerable attention in which 11 companies are participating from Japan, the U.S. and Europe. However, the "rival" for support, the multimedia business, is expected to receive higher priority.

According to Vice President Yoshitaka Kawasaki of Shin-Etsu Semiconductor, the "16 Inch Wafer has been rated as a rank A project." Therefore, in spite of the delay, the FY96 public funding is likely to be "approved" for allocation.

Efforts surely are under way to produce larger wafers, from 8 inches to 12 inches, and further to 16 inches. However, allocation of responsibility for the astronomical R&D costs incurred during the effort to produce larger wafers still remains uncertain. Some observers seemed perplexed, saying that even the development of 12-inch wafers is uncertain, "let alone 16-inch wafers."

Still it is true that "it is important to meet the challenges of the next generation of technology and better qualified researchers will be attracted to the project," said Kawasaki. The scenario toward commercialization depends on how the 16-inch wafer technology, once developed, can be applied back to production of 12-inch wafers.

Nuclear Power Plant Troubles That Occurred in FY93

94FE0774A Tokyo SHIGEN ENERUGICHO in Japanese 6 Apr 94 pp 1-15

[A report by the Governmental Materials Dissemination and Survey Council, Materials Center]

[FBIS Translated Text]

Agency of Natural Resources and Energy (ANRE) (Inquiries) Nuclear Power Operations Management Office, 3501-1739 Ext. 3807

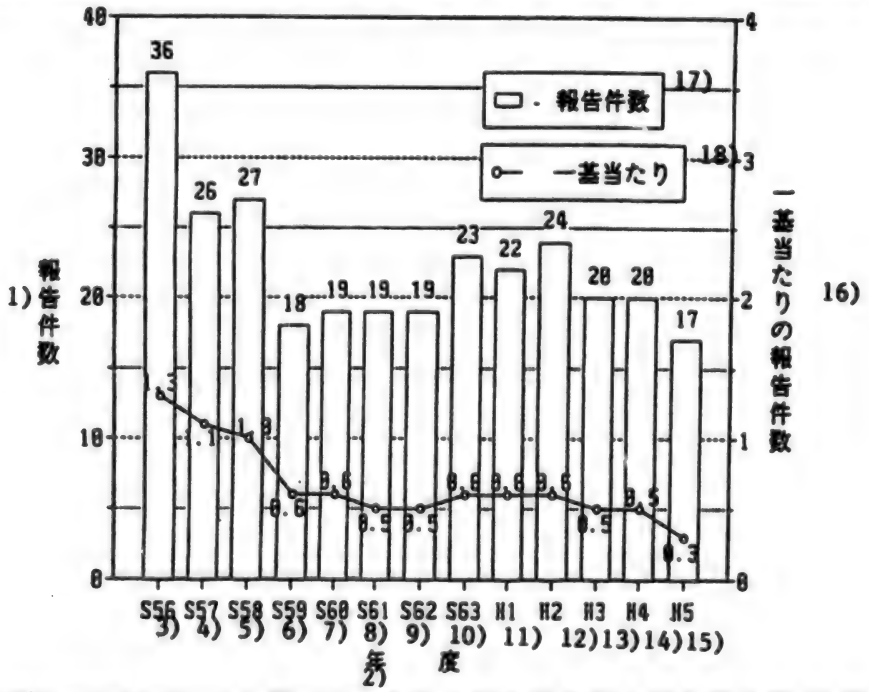
1. During FY1993 there were 17 incidents of trouble occurring in nuclear power plants. In accordance with laws such as the "Law Concerning the Regulation of Nuclear Substances and Nuclear Reactors," those incidents were reported by electric power companies to the Agency of Natural Resources and Energy (ANRE).
2. In 10 of the incidents, reactors that were in operation (including reactors being tested or adjusted) were manually shut down. In the other seven incidents, problems were discovered in shut-down reactors.
3. In all incidents, there were no effects due to radioactive substances on the environments around the nuclear power plants.

Table 1. Change in Number of Incidents Reported (According to Law)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
BWR	21	13	10	5	10	5	8	8	9	13	6	13	5
PWR	14	13	16	11	8	11	10	12	12	10	13	6	13
GCR	1	0	1	2	1	3	1	3	1	1	1	1	1
Total	36	26	27	18	19	19	19	23	22	24	20	20	17
Number of reported incidents per reactor (number of reactors)	1.3 (23)	1.1 (24)	1.0 (25)	0.6 (28)	0.6 (32)	0.5 (33)	0.5 (35)	0.6 (36)	0.6 (37)	0.6 (39)	0.5 (41)	0.5 (42)	0.3 (46)

(Notes)
1. The number of reactors is the number of commercially operating reactors at the end of the fiscal year.
2. The number of reported incidents per reactor was computed using the number of reported incidents of trouble occurring in commercially operating reactors and the number of reactors.

Figure 1. Changes in Number of Reported Incidents and Number of Reported Incidents per Reactor

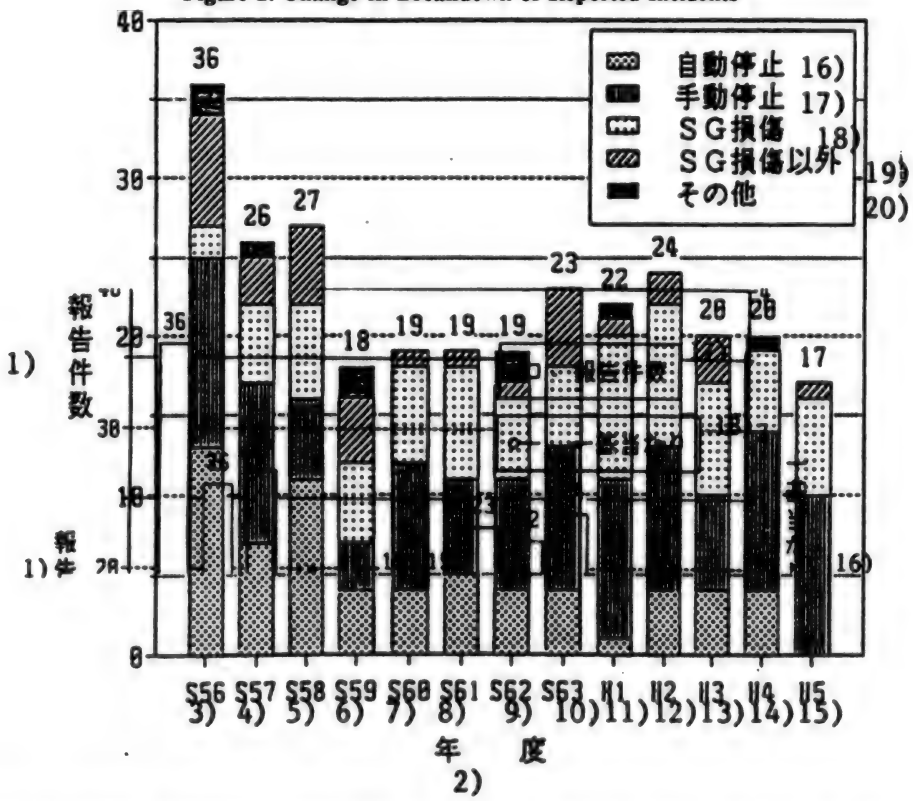


Key: 1. Number of reported incidents 2. Fiscal year 3. 81 4. 82 5. 83 6. 84 7. 85 8. 86 9. 87 10. 88 11. 89 12. 90 13. 91 14. 92 15. 93 16. Number of reported incidents per reactor 17. Number of reported incidents 18. Per reactor

Table 2. Change in Breakdown of Incidents Reported (According to Law)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
In-operation reactors													
Automatically shut down	13	7	11	4	4	5	4	4	1	4	4	4	0
Manually shut down	12	10	5	3	8	6	7	9	10	9	6	10	10
Shut-down reactors													
Damage to steam generator's heat-transfer pipes	2	5	6	5	6	7	5	5	9	9	7	5	8
Damage to something other than steam generator's heat-transfer pipes	7	3	5	4	1	1	1	5	1	2	3	0	1
Other	2	1	0	2	0	0	2	0	1	0	0	1	0
Total number	36	26	27	18	19	19	19	23	22	24	20	20	17

Figure 2. Change in Breakdown of Reported Incidents



Key: 1. Number of reported incidents 2. Fiscal year 3. 81 4. 82 5. 83 6. 84 7. 85 8. 86 9. 87 10. 88 11. 89 12. 90 13. 91 14. 92 15. 93 16. Automatically shut down 17. Manually shut down 18. SG damage 19. Non-SG damage 20. Other

Key: 1. Number of reported incidents 2. Fiscal year 3. 81 4. 82 5. 83 6. 84 7. 85 8. 86 9. 87 10. 88 11. 89 12. 90 13. 91 14. 92 15. 93 16. Number of reported incidents per reactor 17. Number of reported incidents 18. Per reactor

Summary of Nuclear Power Plant Troubles Reported in FY93 (According to Law)

Date of occurrence	Name of nuclear power plant	Summary	Scale
3 Apr 1993	Japan Atomic Power Co.'s Tokai NPP II	During rated output operation, the reactor was manually shut down because an increase in the amount of containment vessel cooler drain was noticed. The causes of the trouble were that the seal water was not discharging and there was leakage from the shaft seal section cover due to extraneous material adhering to the flow detector installed in the seal leak detection pipe of the reactor's recirculation pump.	0-
6 Apr 1993	Kyushu Electric Power Co.'s Genkai NPP No. 1 Reactor	As a result of an over-current flaw detection check of the steam generator's heat-transfer pipes during a periodic inspection, significant indications were observed in part of the tube support plate and directly beneath the tube plate surface.	0-
14 Apr 1993	Japan Atomic Power Co.'s Tokai NPP	As a result of a low-pressure turbine detection check during a periodic inspection, damage to part of the surface where the moving blades are attached to the shaft was observed. The problem was due to stress corrosion cracking caused by thermal effects remaining in the area near the blade attachment pins when the low-pressure turbine was made.	0-
27 Apr 1993	Shikoku Electric Power Co.'s Ikata NPP No. 1 Reactor	As a result of an over-current flaw detection check of the steam generator's heat-transfer pipes during a periodic inspection, significant indications were observed in the tube plate's tube roll.	0-
2 Jun 1993	Kansai Electric Power Co.'s Takahama NPP No. 1 Reactor	As a result of an over-current flaw detection check of the steam generator's heat-transfer pipes during a periodic inspection, significant indications were observed in the U-tube, tube support plate, boundary of the tube plate's tube roll, and the tube plate's tube roll.	0-
29 Jun 1993	Kansai Electric Power Co.'s Mihama NPP No. 1 Reactor	As a result of an over-current flaw detection check of the steam generator's heat-transfer pipes during a periodic inspection, significant indications were observed directly above the tube plate.	0-
17 Jul 1993	Kansai Electric Power Co.'s Takahama NPP No. 1 Reactor	During adjustment operation, the reactor was manually shut down because the water level of the drain sump on the floor of the containment vessel was rising. The problem was due to defects in the welding between the nozzle neck and the vent tube installed in the B-loop main steam pipe, and cracks in that welded part resulting from tiny vibrations accompanying steam flow during operation of the reactor.	0-
29 Jul 1993	Kansai Electric Power Co.'s Oi NPP No. 1 Reactor	As a result of an over-current flaw detection check of the steam generator's heat-transfer pipes during a periodic inspection, significant indications were observed in tube support plate, boundary of the tube plate's tube roll, and the tube plate's tube roll.	0-
18 Aug 1993	Kansai Electric Power Co.'s Takahama NPP No. 1 Reactor	During adjustment operation at rated output, the reactor was manually shut down because the water level of the drain sump at the bottom of the containment vessel was rising. The problem was due to an increase in vibration-induced stress and to cracks that occurred in the welded ends of pipes because the pipe support conditions had changed along with the replacement of pipes for measuring the primary coolant pump (B) and because the characteristic frequency of those pipes was almost the same as the pump's characteristic frequency.	0-
18 Aug 1993	Kansai Electric Power Co.'s Mihama NPP No. 1 Reactor	During a periodic inspection the reactor was manually shut down because the turbine bearing oil pressure was lower than normal when turbine rotation tests were performed. The problem was due to debris (paper for wiping oil, etc.) clogging the bearing oil pressure system.	Not a rated item.
21 Sep 1993	Japan Power Co.'s Tsuruga NPP No. 1 Reactor	During rated output operation the reactor was manually shut down in order to replace the shaft seal (mechanical seal) of the reactor's recirculation pump (B) because the seal's performance dropped.	0-
24 Sep 1993	Kyushu Electric Power Co.'s Genkai NPP No. 3 Reactor	During test operation the reactor was manually shut down because of increasing vibration in the low-pressure turbine shaft. The problem was caused by part of the shaft seal coming in contact with the low-pressure turbine shaft because the space between those had narrowed.	Not a rated item.
9 Nov 1993	Japan Power Co.'s Tsuruga NPP No. 1 Reactor	During rated output operation the reactor was manually shut down because an increase in the amount of containment vessel cooler drain was observed. The trouble was caused by air accumulating among the retained flow rate measurement water due to the flexure in the flexible hose installed in the seal leak detection pipe of the reactor's recirculation pump, and by obstruction of the flow of water in the seal leak detection pipe.	0-

Summary of Nuclear Power Plant Troubles Reported in FY93 (According to Law) (Continued)

Date of occurrence	Name of nuclear power plant	Summary	Scale
16 Nov 1993	Kansai Electric Power Co.'s Mihama NPP No. 3 Reactor	As a result of an over-current flaw detection check of the steam generator's heat-transfer pipes during a periodic inspection, significant indications were observed in the tube support plate, boundary of the tube plate's tube roll, and the tube plate's tube roll.	0-
2 Dec 1993	Tohoku Electric Power Co.'s Onagawa NPP No. 1 Reactor	During startup the reactor was manually shut down because reverse rotation of a halted reactor water supply pump (B) was observed when a reactor water supply pump (C) was started up. The problem occurred because the lock nut of the discharge check valve of the reactor water supply pump (B) became worn down by the surging of the supply water because it was not tightened enough, and the valve became unseated.	0-
22 Dec 1993	Japan Power Co.'s Tsuruga NPP No. 1 Reactor	During rated output operation the reactor was manually shut down because an increase in the amount of containment vessel cooler drain was observed. The trouble occurred because of cracking in the welded part of the differential measurement takeoff pipe of the emergency condenser system (A) due to resonance because the characteristic frequency of the differential measurement takeoff pipe was almost the same as the oscillation frequency concomitant with rotation of the reactor's recirculation pump.	0-
18 Feb 1994	Kansai Electric Power Co.'s Mihama NPP No. 1 Reactor	During rated output operation, the reactor was manually shut down because the indicated value of the gas monitor of the condenser's air ejector rose.	0+ provisional evaluation

Number of Past Incidents Reported (According to Law, Part 1)

Name of founder	Name of power plant		Output (10,000 kW)	Date of initial operation	FY66	FY67	FY68	FY69	FY70	FY71	FY72	FY73	FY74	FY75
Japan Atomic Power	Tokai		16.6	2 Jul 67	13	6	4	2	0	1	0	0	0	0
	Tokai II		110.0	28 Nov 68										
	Tsuruga	No. 1	35.7	14 Mar 70				1	2	8	2	0	3	2
	Tsuruga	No. 2	116.0	17 Feb 87										
Hokkaido EPC	Tomari	No. 1	57.9	22 Jun 89										
	Tomari	No. 2	57.9	12 Apr 91										
Tohoku EPC	Onagawa	No. 1	52.4	1 Jun 84										
Tokyo EPC	Fukushima I	No. 1	46.0	26 Mar 71					0	1	4	1	1	1
		No. 2	78.4	18 Jul 74									2	2
		No. 3	78.4	27 Mar 76										0
		No. 4	78.4	12 Oct 78										
		No. 5	78.4	18 Apr 78										
		No. 6	110.0	24 Oct 79										
	Fukushima II	No. 1	110.0	20 Apr 82										
		No. 2	110.0	3 Feb 84										
		No. 3	110.0	21 Jun 85										
		No. 4	110.0	25 Aug 87										
	Kashiwazaki	No. 1	110.0	18 Sep 85										
	Kariwa	No. 2	110.0	28 Sep 90										
		No. 3	110.0	11 Aug 93										
		No. 5	110.0	10 Apr 90										
Chubu EPC	Hamaoka	No. 1	54.0	17 Mar 76										1
		No. 2	84.0	29 Nov 78										
		No. 3	110.0	28 Aug 87										
		No. 4	113.7	3 Sep 93										
Kansai EPC	Mihama	No. 1	34.0	28 Nov 70					1	3	1	2	1	0
		No. 2	50.0	25 Jul 72							2	2	3	0
		No. 3	82.6	1 Dec 76										
	Takahama	No. 1	82.6	14 Nov 74									3	1
		No. 2	82.6	14 Nov 75										0
		No. 3	87.0	17 Jan 85										
		No. 4	87.0	5 Jun 85										
	Oi	No. 1	117.5	27 Mar 79										
		No. 2	117.5	5 Dec 79										
		No. 3	118.0	18 Dec 91										
		No. 4	118.0	2 Feb 93										
Chugoku EPC	Shimane	No. 1	46.0	29 Mar 74								0	0	0
		No. 2	82.0	10 Feb 89										
Shikoku EPC	Ikata	No. 1	56.6	30 Sep 77										
		No. 2	56.6	19 Mar 82										
Kyushu EPC	Genkai	No. 1	55.9	15 Oct 75										1(1)
		No. 2	55.9	30 Mar 81										
		No. 3	118.0	18 Mar 94										
	Sendai	No. 1	89.0	4 Jul 84										
		No. 2	89.0	28 Nov 85										
Total					13	6	4	3	3	13	9	5	13	8(1)
No. of reactors					1	1	1	2	4	4	5	6	8	12
No. of incidents reported per reactor					13.0	6.0	4.0	1.5	0.8	3.3	1.8	0.8	1.6	0.6

Notes: 1. Numbers in parentheses indicate number of reported incidents occurring in reactors undergoing test operations.
2. Number of reactors that are commercially operating reactors at end of the fiscal year.
3. Number of reported incidents per reactor computed using number of reported incidents of trouble occurring in commercially operating reactors and number of reactors.

Number of Past Incidents Reported (According to Law, Part 2)

Name of founder	Name of power plant	Output (10,000 kW)	Date of initial operation	FY89	FY90	FY91	FY92	FY93	Total
Japan Atomic Power	Tokai	16.6	2 Jul 1966	1	1	1	1	1	45
	Tokai II	110.0	28 Nov 1978	1	1	0	0	1	20
	Tsuruga No. 1	35.7	14 Mar 1970	1	1	1	0	3	47
	Tsuruga No. 2	116.0	17 Feb 1987	1	1	0	0	0	4(1)
Hokkaido EPC	Tomari No. 1	57.9	22 Jun 1989	0	0	1	0	0	1
	Tomari No. 2	57.9	12 Apr 1991		1	0	0	1	
Tohoku EPC	Onagawa No. 1	52.4	1 Jun 1984	0	1	0	1	1	5
Tokyo EPC	Fukushima I No. 1	46.0	26 Mar 1971	0	1	1	1	0	32
	Fukushima I No. 2	78.4	18 Jul 1974	0	1	1	2	0	24
	Fukushima I No. 3	78.4	27 Mar 1976	0	2	0	0	0	14
	Fukushima I No. 4	78.4	12 Oct 1978	0	0	0	0	0	6
	Fukushima I No. 5	78.4	18 Apr 1978	0	0	0	0	0	11
	Fukushima I No. 6	110.0	24 Oct 1979	0	0	0	2	0	9
	Fukushima II No. 1	110.0	20 Apr 1982	2	1	1	2	0	16(6)
	Fukushima II No. 2	110.0	3 Feb 1984	1	0	0	0	0	2
	Fukushima II No. 3	110.0	21 Jun 1985	0	0	0	1	0	5
	Fukushima II No. 4	110.0	25 Aug 1987	1	1	0	0	0	2
	Kashiwazaki Kariwa No. 1	110.0	18 Sep 1985	0	0	0	1	0	1
	Kashiwazaki Kariwa No. 2	110.0	28 Sep 1990		1	0	1	0	2
	Kashiwazaki Kariwa No. 3	110.0	11 Aug 1993					0	0
	Kashiwazaki Kariwa No. 5	110.0	10 Apr 1990		0	0	0	0	0
Chubu EPC	Hamaoka No. 1	54.0	17 Mar 1976	0	1	0	0	0	14
	Hamaoka No. 2	84.0	29 Nov 1978	0	0	0	0	0	5
	Hamaoka No. 3	110.0	28 Aug 1987	1	0	1	0	0	2
	Hamaoka No. 4	113.7	9 Mar 1993					0	0

Number of Past Incidents Reported (According to Law, Part 2) (Continued)

Name of founder	Name of power plant	Output (10,000 kW)	Date of initial operation	FY89	FY90	FY91	FY92	FY93	Total
Kansai EPC	Mihama No. 1	34.0	28 Nov 1970	1	0	1	1	3	20
	Mihama No. 2	50.0	25 Jul 1972	0	2	0	0	0	19
	Mihama No. 3	82.6	1 Dec 1976	1	1	0	1	1	18
	Takahama No. 1	82.6	14 Nov 1974	1	1	1	1	3	28
	Takahama No. 2	82.6	14 Nov 1975	0	1	1	1	0	23
	Takahama No. 3	87.0	17 Jan 1985	1	1	0	0	0	5 (1)
	Takahama No. 4	87.0	5 Jun 1985	1	0	0	0	0	1
	Oi No. 1	117.5	27 Mar 1979	2	1	1	0	1	32 (1)
	Oi No. 2	117.5	5 Dec 1979	1	0	2	1	0	21
	Oi No. 3	118.0	18 Dec 1991			0	0	0	0
	Oi No. 4	118.0	2 Feb 1993				0	0	0
Chugoku EPC	Shimane No. 1	46.0	29 Mar 1974	1	0	1	1	0	5
	Shimane No. 2	82.0	10 Feb 1989	1	2	0	1	0	4
Shikoku EPC	Ikata No. 1	56.6	30 Sep 1977	1	1	1	0	1	11
	Ikata No. 2	56.6	19 Mar 1982	0	0	0	1	0	1
Kyushu EPC	Genkai No. 1	55.9	15 Oct 1975	1	1	1	0	1	16 (1)
	Genkai No. 2	55.9	30 Mar 1981	1	0	0	0	0	2 (1)
	Genkai No. 3	118.0	18 Mar 1994					1(1)	1 (1)
	Sendai No. 1	89.0	4 Jul 1984	0	0	2	0	0	3 (1)
	Sendai No. 2	89.0	28 Nov 1985	0	0	1	0	0	3
Total				22	24	20	20	17	481 (13)
Number of reactors				37	39	41	42	46	574
Number of incidents reported per reactor				0.6	0.6	0.5	0.5	0.3	0.8

(Notes) 1. The numbers in parentheses indicate the number of reported incidents that occurred in reactors undergoing test operations. 2. The number of reactors is the number of commercially operating reactors at the end of the fiscal year. 3. The number of reported incidents per reactor was computed using the number of reported incidents of trouble occurring in commercially operating reactors and the number of reactors.

Appendix 1—Reports Based on the Minister's Notifications

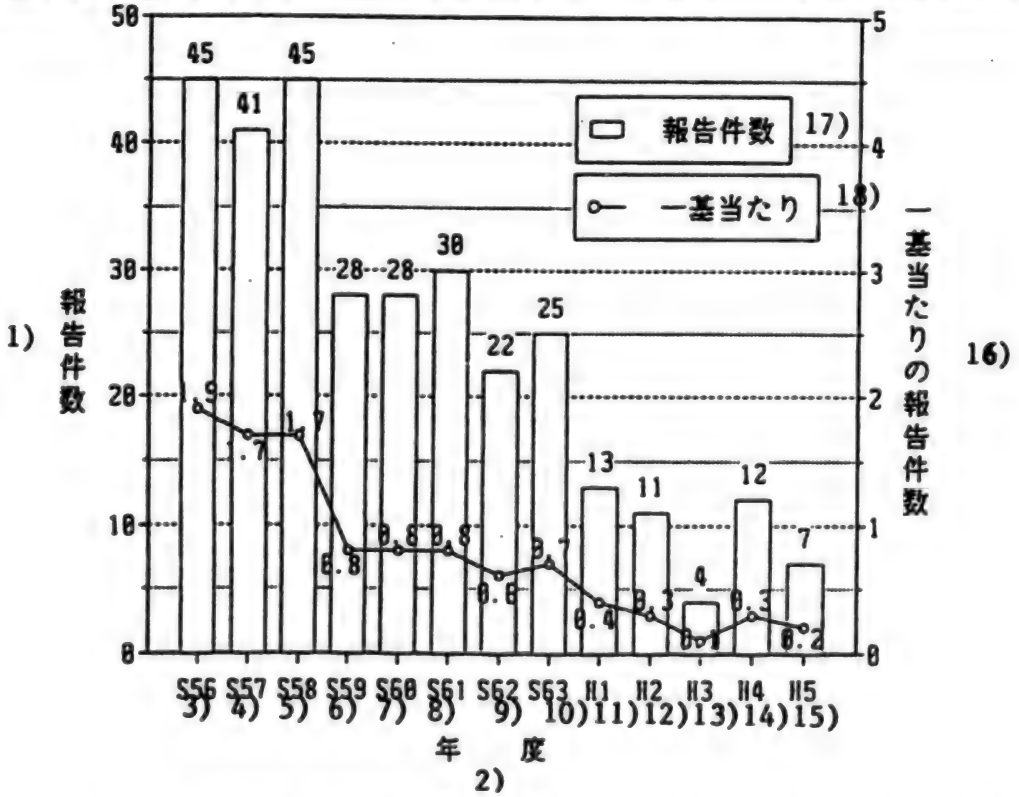
1. During FY1993 there were seven incidents of trouble occurring in nuclear power plants. In accordance with a notification by the Minister for International Trade and Industry, those incidents were reported by electric power companies to the Agency of Natural Resources and Energy (ANRE).
2. In four of the incidents, problems occurred in reactors that were in operation (including reactors being tested or adjusted). In the other three incidents, trouble was discovered in shut-down reactors.
3. In all incidents, there were no effects due to radioactive substances on the environments around the nuclear power plants.

Table 3. Change in Number of Incidents Reported (According to Minister's Notification)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
BWR	33	24	25	9	12	13	12	9	6	4	1	3	6
PWR	8	11	12	14	10	15	9	16	4	2	2	6	1
GCR	4	6	8	5	6	2	1	0	3	5	1	3	0
Total	45	41	45	28	28	30	22	25	13	11	4	12	7
Number of reported incidents per reactor (Number of reactors)	1.9 (23)	1.7 (24)	1.7 (25)	0.8 (28)	0.8 (32)	0.8 (33)	0.6 (35)	0.7 (36)	0.4 (37)	0.3 (39)	0.1 (41)	0.3 (42)	0.2 (46)

(Notes)
1. The number of reactors is the number of commercially operating reactors at the end of the fiscal year.
2. The number of reported incidents per reactor was computed using the number of reported incidents of trouble occurring in commercially operating reactors and the number of reactors.

Figure 3. Changes in Number of Reported Incidents and Number of Reported Incidents per Reactor

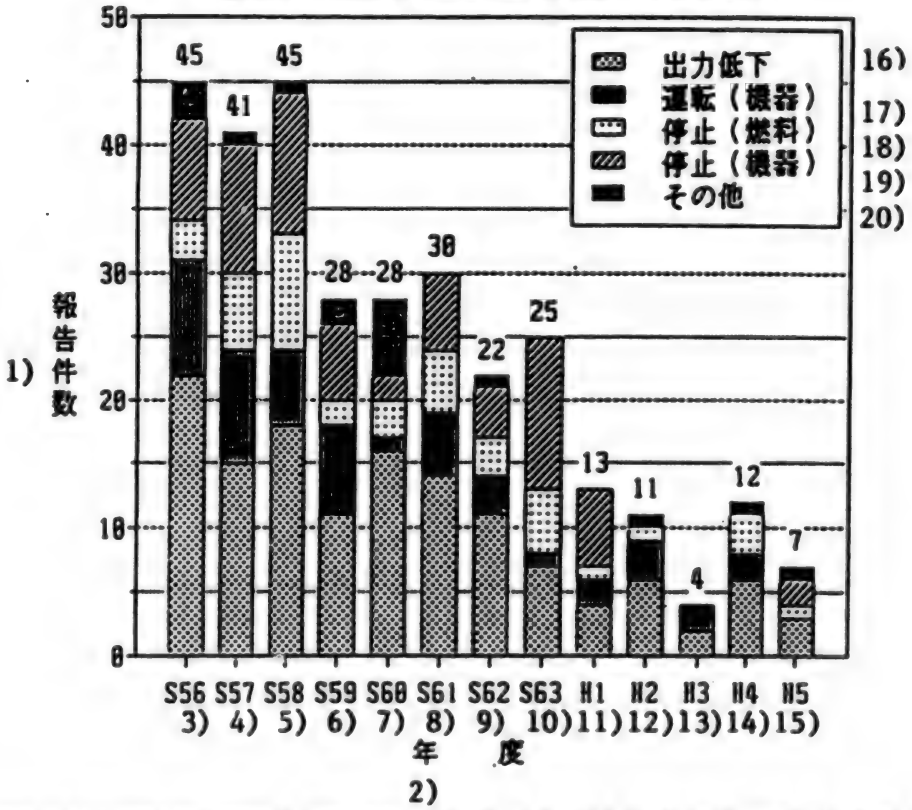


Key: 1. Number of reported incidents 2. Fiscal year 3. 81 4. 82 5. 83 6. 84 7. 85 8. 86 9. 87 10. 88 11. 89 12. 90 13. 91 14. 92 15. 93 16. Number of reported incidents per reactor 17. Number of reported incidents 18. Per reactor

Table 4. Change in Breakdown of Incidents Reported (According to Minister's Notification)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
In-operation reactors													
Unplanned drop in output, etc.	22	15	18	11	16	14	11	7	4	6	2	6	3
Minor problems with equipment	9	9	6	71	5	3	1	2	3	2	2	0	
Shut-down reactors													
Damage involving fuel assemblies	3	6	9	2	3	5	3	5	1	1	0	3	1
Minor problems with equipment	8	10	11	6	2	6	4	12	6	0	0	0	2
Other	3	1	1	2	6	0	1	0	0	1	0	1	1
Total number	45	41	45	28	28	30	22	25	13	11	4	12	7

Figure 4. Change in Breakdown of Reported Incidents



Key: 1. Number of reported incidents 2. Fiscal year 3. 81 4. 82 5. 83 6. 84 7. 85 8. 86 9. 87 10. 88 11. 89 12. 90 13. 91 14. 92 15. 93 16. Drop in output 17. In-operation (equipment) 18. Shut-down (fuel) 19. Shut-down (equipment) 20. Other

Summary of Nuclear Power Plant Trouble Reported (According to Minister's Notification)

Date of occurrence	Name of nuclear power plant	Summary	Scale
26 Apr 1993	Tokyo EPC's Fukushima NPP I No. 5 Reactor	During a periodic inspection a liquid seepage flaw detection check of the outlets of the measurement pipes of the reactor's recirculation system resulted in the discovery of cracks. The problem was due to stress corrosion cracking that occurred because sensitization and residual stress occurred in the materials of the measurement pipe fittings with the excessive heat input during the welding of those fittings and because dissolved oxygen was used in the hot water during operation.	0-
6 Jul 1993	Tokyo EPC's Fukushima NPP I No. 3 Reactor	During adjustment operation at rated output, the reactor's recirculation pump (A) shut down because the power supply device that drives the pump malfunctioned and the pressure of the lubricating oil dropped. The output fell to about 340,000 kW. The problem was due to the malfunctioning pump power supply device and problems with the lubricating oil system's pressure regulator.	0-
24 Aug 1993	Kansai EPC's Mihama NPP No. 3 Reactor	During rated output operation a small amount of seawater leaked into the steam condenser.	Not an evaluated item.
22 Nov 1993	Tokyo EPC's Fukushima NPP II No. 1 Reactor	When the steam dryer was checked during a periodic inspection, a crack was discovered in a welded part of the drain channel. The problem occurred because the welding was not thick enough, stress increased along with vibration of the drain channel due to fluctuations in the steam pressure, and fatigue cracking occurred.	
27 Nov 1993	Tohoku EPC's Onagawa NPP No. 1 Reactor	During rated output operation the reactor was automatically shut down because of a "high neutron flux" message. The problem was due to a change in the state of the voids (steam bubbles) when an earthquake occurred, and increased neutron flux.	
28 Feb 1994	Tokyo EPC's Fukushima NPP I No. 6 Reactor	During adjustment operation at rated output, the reactor was manually shut down because of a drop in the pressure of the hydrogen gas used for cooling the inside of the generator. The problem occurred because the packing of the flange of the washer used for detecting a short circuit in the generator was fastened incorrectly.	Not an evaluated item.
17 Mar 1994	Tokyo EPC's Fukushima NPP I No. 5 Reactor	During an intermediate shutdown, leakage in one fuel rod was discovered.	0-

Number of Past Incidents Reported (According to Law, Part 2)

Name of founder	Name of power plant		Output (10,000 kW)	Date of initial operation	FY76	FY77	FY78	FY79	FY80	FY81	FY82	FY83	FY84	FY85
Japan Atomic Power	Tokai		16.6	2 Jul 67	0	1	0	1	0	1	0	1	2	1
	Tokai II		110.0	28 Nov 68			2	1	3	4	3	1	2	1
	Tsuruga	No. 1	35.7	14 Mar 70	2	4	3	2	2	2	1	3	0	2
	Tsuruga	No. 2	116.0	17 Feb 87										
Hokkaido EPC	Tomari	No. 1	57.9	22 Jun 89										
	Tomari	No. 2	57.9	12 Apr 91										
Tohoku EPC	Onagawa	No. 1	52.4	1 Jun 84									0	1
Tokyo EPC	Fukushima I	No. 1	46.0	26 Mar 71	5	2	2	3	1	2	2	2	0	2
		No. 2	78.4	18 Jul 74	5	2	1	1	2	2	0	1	1	0
		No. 3	78.4	27 Mar 76	5	2	1	1	1	0	1	0	0	0
		No. 4	78.4	12 Oct 78			1	1	2	0	0	1	0	1
		No. 5	78.4	18 Apr 78			0	0	0	2	3	1	0	1
		No. 6	110.0	24 Oct 79				0	1	1	3	1	0	0
	Fukushima II	No. 1	110.0	20 Apr 82						6(6)	0	0	2	0
		No. 2	110.0	3 Feb 84								0	0	1
		No. 3	110.0	21 Jun 85										1
		No. 4	110.0	25 Aug 87										
	Kashiwazaki	No. 1	110.0	18 Sep 85										0
	Kariwa	No. 2	110.0	28 Sep 90										
		No. 3	110.0	11 Aug 93										
		No. 5	110.0	10 Apr 90										
Chubu EPC	Hamaoka	No. 1	54.0	17 Mar 76	1	3	1	2	1	1	0	0	0	0
		No. 2	84.0	29 Nov 78			0	0	1	1	0	0	0	0
		No. 3	110.0	28 Aug 87										
		No. 4	113.7	3 Sep 93										
Kansai EPC	Mihama	No. 1	34.0	28 Nov 70	0	0	0	0	0	4	1	1	0	0
		No. 2	50.0	25 Jul 72	1	0	0	3	0	0	2	1	1	0
		No. 3	82.6	1 Dec 76	0	1	2	1	1	0	0	3	1	2
	Takahama	No. 1	82.6	14 Nov 74	3	0	2	2	2	0	1	1	1	2
		No. 2	82.6	14 Nov 75	0	2	3	2	0	2	2	2	2	0
		No. 3	87.0	17 Jan 85									1(1)	0
		No. 4	87.0	5 Jun 85										0
	Oi	No. 1	117.5	27 Mar 79			1(1)	5	4	5	2	3	0	1
		No. 2	117.5	5 Dec 79				0	2	2	4	1	4	1
		No. 3	118.0	18 Dec 91										
		No. 4	118.0	2 Feb 93										
Chugoku EPC	Shimane	No. 1	46.0	29 Mar 74	2	0	0	0	0	0	0	0	0	0
		No. 2	82.0	10 Feb 89										
Shikoku EPC	Ikata	No. 1	56.6	30 Sep 77		0	2	1	1	0	0	1	0	1
		No. 2	56.6	19 Mar 82						0	0	0	0	0
Kyushu EPC	Genkai	No. 1	55.9	15 Oct 75	0	0	1	0	0	1	1	2	1	1
		No. 2	55.9	30 Mar 81					1(1)	0	0	0	0	0
		No. 3	118.0	18 Mar 94										
	Sendai	No. 1	89.0	4 Jul 84								1(1)	0	0
		No. 2	89.0	28 Nov 85										0
Total					24	17	22(1)	26	25(1)	36(6)	26	27(1)	18(1)	19
No. of reactors					13	14	19	21	22	23	24	25	28	32
No. of incidents reported per reactor					1.8	1.2	1.1	1.2	1.1	1.3	1.1	1.0	0.6	0.6

Notes: 1. Numbers in parentheses indicate number of reported incidents occurring in reactors undergoing test operations.
2. Number of reactors that are commercially operating reactors at end of the fiscal year.
3. Number of reported incidents per reactor computed using number of reported incidents of trouble occurring in commercially operating reactors and number of reactors.

Number of Past Incidents Reported (According to Law, Part 3)

Name of founder	Name of power plant		Output (10,000 kW)	Date of initial operation	FY86	FY87	FY88	FY89	FY90	FY91	FY92	FY93	Total
Japan Atomic Power	Tokai		16.6	2 Jul 67	3	1	3	1	1	1	1	1	45
	Tokai II		110.0	28 Nov 98	0	0	0	1	1	0	0	1	20
	Tsuruga	No. 1	35.7	14 Mar 70	0	2	0	1	1	1	0	3	47
	Tsuruga	No. 2	116.0	17 Feb 87	1(1)	1	0	1	1	0	0	0	4(1)
Hokkaido EPC	Tomari	No. 1	57.9	22 Jun 89				0	0	1	0	0	1
	Tomari	No. 2	57.9	12 Apr 91						1	0	0	1
Tohoku EPC	Onagawa	No. 1	52.4	1 Jun 84	0	1	0	0	1	0	1	1	5
Tokyo EPC	Fukushima I	No. 1	46.0	26 Mar 71	0	0	0	0	1	1	1	0	32
		No. 2	78.4	18 Jul 74	1	0	0	0	1	1	2	0	24
		No. 3	78.4	27 Mar 76	0	0	1	0	2	0	0	0	14
		No. 4	78.4	12 Oct 78	0	0	0	0	0	0	0	0	6
		No. 5	78.4	18 Apr 78	2	1	1	0	0	0	0	0	11
		No. 6	110.0	24 Oct 79	1	0	0	0	1	0	2	0	9
	Fukushima II	No. 1	110.0	20 Apr 82	1	1	0	2	0	1	2	0	16(6)
		No. 2	110.0	3 Feb 84	0	0	0	1	0	0	0	0	2
		No. 3	110.0	21 Jun 85	0	0	3	0	0	0	1	0	5
		No. 4	110.0	25 Aug 87		0	0	1	1	0	0	0	2
	Kashiwazaki Kariwa	No. 1	110.0	18 Sep 85	0	0	0	0	0	0	1	0	1
		No. 2	110.0	28 Sep 90					1	0	1	0	2
		No. 3	110.0	11 Aug 93								0	0
		No. 5	110.0	10 Apr 90					0	0	0	0	0
Chubu EPC	Hamaoka	No. 1	54.0	17 Mar 76	0	2	1	0	1	0	0	0	14
		No. 2	84.0	29 Nov 78	0	1	2	0	0	0	0	0	5
		No. 3	110.0	28 Aug 87		0	0	1	0	1	0	0	2
		No. 4	113.7	3 Sep 93								0	0
Kansai EPC	Mihama	No. 1	34.0	28 Nov 70	0	0	0	1	0	1	1	3	20
		No. 2	50.0	25 Jul 72	1	1	0	0	2	0	0	0	19
		No. 3	82.6	1 Dec 76	1	1	1	1	1	0	1	1	18
	Takahama	No. 1	82.6	14 Nov 74	1	1	1	1	1	1	1	3	28
		No. 2	82.6	14 Nov 75	2	1	2	0	1	1	1	0	23
		No. 3	87.0	17 Jan 85	0	1	1	1	1	0	0	0	5(1)
		No. 4	87.0	5 Jun 85	0	0	0	1	0	0	0	0	1
	Oi	No. 1	117.5	27 Mar 79	0	2	2	2	1	1	0	1	32(1)
		No. 2	117.5	5 Dec 79	0	1	2	1	0	2	1	0	21
		No. 3	118.0	18 Dec 91						0	0	0	0
		No. 4	118.0	2 Feb 93							0	0	0
Chugoku EPC	Shimane	No. 1	46.0	29 Mar 74	0	0	0	1	0	1	1	0	5
		No. 2	82.0	10 Feb 89			0	1	2	0	1	0	4
Shikoku EPC	Ikata	No. 1	56.6	30 Sep 77	1	0	0	1	1	1	0	1	11
		No. 2	56.6	19 Mar 82	0	0	0	0	0	0	1	0	1
Kyushu EPC	Genkai	No. 1	55.9	15 Oct 75	2	1	1	1	1	1	0	1	16(1)
		No. 2	55.9	30 Mar 81	0	0	0	1	0	0	0	0	2(1)
		No. 3	118.0	18 Mar 94								1(1)	1(1)
	Sendai	No. 1	89.0	4 Jul 84	0	0	0	0	0	2	0	0	3(1)
		No. 2	89.0	28 Nov 85	0	0	2	0	0	1	0	0	3
Total					19(1)	19	23	22	24	20	20	17	481(13)
No. of reactors					33	35	36	37	39	41	42	46	574
No. of incidents reported per reactor					0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.3	0.8

Notes: 1. Numbers in parentheses indicate number of reported incidents occurring in reactors undergoing test operations.
2. Number of reactors that are commercially operating reactors at end of the fiscal year.
3. Number of reported incidents per reactor computed using number of reported incidents of trouble occurring in commercially operating reactors and number of reactors.

Number of Past Incidents Reported (According to Minister's Notification, Part 2)

Name of founder	Name of power plant	Output (10,000 kW)	Date of initial operation	FY89	FY90	FY91	FY92	FY93	Total
Japan Atomic Power	Tokai	16.6	2 Jul 1966	3	5	1	3	0	44
	Tokai II	110.0	28 Nov 1978	0	1	0	0	0	21
	Tsuruga No. 1	35.7	14 Mar 1970	1	0	0	0	0	21
	Tsuruga No. 2	116.0	17 Feb 1987	0	0	0	1	0	5(2)
Hokaido EPC	Tomari No. 1	57.9	22 Jun 1989	0	1	0	0	0	1
	Tomari No. 2	57.9	12 Apr 1991		0	0	0	0	
Tohoku EPC	Onagawa No. 1	52.4	1 Jun 1984	1	0	1	0	1	7(2)
Tokyo EPC	Fukushima I No. 1	46.0	26 Mar 1971	2	0	0	0	0	16
	Fukushima I No. 2	78.4	18 Jul 1974	0	0	0	0	0	19
	Fukushima I No. 3	78.4	27 Mar 1976	0	0	0	0	1	8
	Fukushima I No. 4	78.4	12 Oct 1978	0	0	0	1	0	7
	Fukushima I No. 5	78.4	18 Apr 1978	0	0	0	0	2	5
	Fukushima I No. 6	110.0	24 Oct 1979	0	2	0	0	1	14(2)
	Fukushima II No. 1	110.0	20 Apr 1982	1	0	0	0	1	8(1)
	Fukushima II No. 2	110.0	3 Feb 1984	0	0	0	0	0	4
	Fukushima II No. 3	110.0	21 Jun 1985	0	0	0	0	0	1(1)
	Fukushima II No. 4	110.0	25 Aug 1987	0	0	0	1	0	2(1)
	Kashiwazaki Kariwa No. 1	110.0	18 Sep 1985	0	0	0	0	0	2(1)
	Kashiwazaki Kariwa No. 2	110.0	28 Sep 1990		0	0	0	0	0
	Kashiwazaki Kariwa No. 3	110.0	11 Aug 1993					0	0
	Kashiwazaki Kariwa No. 5	110.0	10 Apr 1990		0	0	0	0	0
Chubu EPC	Hamaoka No. 1	54.0	17 Mar 1976	0	0	0	0	0	15
	Hamaoka No. 2	84.0	29 Nov 1978	1	1	0	1	0	13
	Hamaoka No. 3	110.0	28 Aug 1987	1	0	1	0	0	2
	Hamaoka No. 4	113.7	9 Mar 1993					0	0

Number of Past Incidents Reported (According to Minister's Notification, Part 2) (Continued)

Name of founder	Name of power plant	Output (10,000 kW)	Date of initial operation	FY89	FY90	FY91	FY92	FY93	Total
Kansai EPC	Mihama No. 1	34.0	28 Nov 1970	0	0	0	0	0	7
	Mihama No. 2	50.0	25 Jul 1972	0	0	0	0	0	10
	Mihama No. 3	82.6	1 Dec 1976	0	0	0	1	1	10
	Takahama No. 1	82.6	14 Nov 1974	0	0	0	2	0	14
	Takahama No. 2	82.6	14 Nov 1975	0	0	0	0	0	8
	Takahama No. 3	87.0	17 Jan 1985	1	0	0	0	0	6 (3)
	Takahama No. 4	87.0	5 Jun 1985	1	0	0	0	0	4 (2)
	Oi No. 1	117.5	27 Mar 1979	1	1	0	0	0	14
	Oi No. 2	117.5	5 Dec 1979	0	0	2	1	0	15
	Oi No. 3	118.0	18 Dec 1991			0	0	0	0
	Oi No. 4	118.0	2 Feb 1993				0	0	0
Chugoku EPC	Shimane No. 1	46.0	29 Mar 1974	0	0	0	0	0	6
	Shimane No. 2	82.0	10 Feb 1989	0	1	0	0	0	1 (1)
Shikoku EPC	Ikata No. 1	56.6	30 Sep 1977	1	0	0	0	0	6
	Ikata No. 2	56.6	19 Mar 1982	0	0	0	1	0	5
Kyushu EPC	Genkai No. 1	55.9	15 Oct 1975	0	0	0	0	5	
	Genkai No. 2	55.9	30 Mar 1981	0	0	0	0	0	4 (1)
	Genkai No. 3	118.0	18 Mar 1994					0	0
	Sendai No. 1	89.0	4 Jul 1984	0	0	0	0	0	2
	Sendai No. 2	89.0	28 Nov 1985	0	0	0	0	0	2 (1)
Total				13	11	4	12	7	334 (18)
Number of reactors				37	39	41	42	46	574
Number of incidents reported per reactor				0.4	0.3	0.1	0.3	0.2	0.6

(Notes)
1. The numbers in parentheses indicate the number of reported incidents that occurred in reactors undergoing test operations.
2. The number of reactors is the number of commercially operating reactors at the end of the fiscal year.
3. The number of reported incidents per reactor was computed using the number of reported incidents of trouble occurring in commercially operating reactors and the number of reactors.

Appendix 2—About the International Nuclear Event Evaluation Scale (INES)

Evaluations of problems that have occurred in nuclear power plants since 1 August 1992 are based on the International Nuclear Event Evaluation Scale (INES). The evaluation results are as follows.

	Events not covered in INES	Level 0-	Level 0+	Level 1	Total
FY1992	6	8	4	2	20
FY93	4	18	2	0	24
Total	10	26	6	2	44

Notes: The fiscal year classifications are based on the date of occurrence. Two provisional evaluations are included (one event not covered by INES and one Level 0+ event.)

Group Finds Better Way To Obtain Uranium

43070028A Tokyo THE NIKKEI WEEKLY in English 19 Dec 94 p 12

[FBIS Transcribed Text] In a move designed to ease foreign suspicions that Japan may secretly divert its huge stock of plutonium to military use, the Science and Technology Agency has undertaken its most comprehensive disclosure program yet. Last week the agency revealed detailed information on where and how much plutonium exists in the country's overall nuclear-fuel recycling program.

According to the data, included in the agency's annual white paper on nuclear energy, a total of 4,684 kg of plutonium was being stored in Japan as of the end of 1993.

In addition, 6,197 kg of Japanese-owned plutonium is being held at French and British reprocessing plants.

Of the domestic total, 326 kg was stored at a reprocessing plant in Tokai Village, Ibaraki Prefecture, 3,269 kg at a plutonium-fuel fabrication plant in the same village and 1,089 kg at the Monju fast-breeder reactor facility in Tsuruga, Fukui Prefecture and other civilian facilities fueled by plutonium.

The depth of the government's concern to ensure nuclear transparency is evident in the agency's plan to publish such information on the Internet.

"We hope this will help convince people (in other countries) that Japan's nuclear program is different from North Korea's," said one agency official.

Plutonium Stocks Disclosed by Agency

43070028B Tokyo THE NIKKEI WEEKLY in English 28 Nov 94 p 4

[FBIS Transcribed Text] The world's ocean waters contain an estimated 4.5 billion metric tons of uranium. The problem is that the uranium exists in the extremely dilute concentration of 3 mg per ton of sea water. The trick, then, is to develop an effective way of separating it out.

With that aim in mind, a special material with high affinity for uranium has been developed by a research group from the Japan Atomic Energy Research Institute and the University of Tokyo.

Costly process

Placed like a filter in the path of ocean currents, the material is nearly 10 times better at collecting uranium than conventional titanium oxide-based materials, the researchers said. Once collected, the uranium can be recovered using chemical processes.

Although filtering through the oceans for uranium is now about five times more expensive than mining uranium ores, the cost could be lowered by improving on the material and the recovery process, the researchers said.

The institute plans to design a pilot plant next year in order to promote the technology as a way to take advantage of mineral resources in sea water.

The new collecting material is made by activating the surface of a polyester hollow fiber membrane with gamma rays and then graft-polymerizing to this a special functional group with high affinity for uranium.

In tests simulating an ocean current of 4 cm per second, 1 kg of this material collected 2.7 grams of uranium over a 20-day period.

For practical use, the group envisions fixing a number of disks made of this material in a row like a streamer, and then lowering this structure into the sea.

The material gathers titanium and vanadium in addition to uranium, and all three substances are relatively easy to separate. In addition, by modifying the functional group, it may be possible to gather other rare metals, the researchers said.

JAERI Develops New Method To Measure Pressure Vessel Deterioration

95P60116A Tokyo NIKKEI SANGYO SHIMBUN in Japanese 31 Jan 95 p 5

[FBIS Translated Text]

Based on Magnetic Property

The Japan Atomic Energy Research Institute (JAERI) has developed a new method with which the extent of deterioration of pressure vessels at nuclear power plants can be measured through a non-destructive testing method. JAERI noticed that the magnetic property of the pressure vessel changes as it gets more brittle. Based on this finding, JAERI researchers were able to inspect the degree of deterioration by placing an electromagnet-like device inside the nuclear reactor and magnetizing certain sections. In order to pursue commercialization of

the device, JAERI plans to start a joint research program with utility companies and universities before the end of 1995. Meanwhile, handling of old nuclear reactors and problems of using nuclear reactors for longer periods of time are matter of concern. The newly developed technology looks useful for preparing objective data to cope with such issues.

Irradiation embrittlement occurs in the nuclear power plant's pressure vessel as a result of exposure to neutron beams during nuclear reaction, disturbing the metallic atom configuration. The pressure vessel is made of strong magnetic materials, mainly iron, but as it becomes brittle, its coercive force to maintain magnetism increases. The degree of deterioration can be evaluated by measuring this coercive force.

Specifically, a metallic device called a "magnetic yoke" is attached to the interior wall of the pressure vessel. The magnetic yoke is made of iron measuring 20 centimeters in length. By passing a current through a coil wound around the yoke the area of the pressure vessel wall around the yoke gets magnetized.

Monju's FBR Fuel Exchange Unnecessary

95FE0156A Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 13 Oct 94 p 1

[FBIS Translated Text] On 5 October 1994, the Power Reactor and Nuclear Fuel Development Corporation (PNC) revealed to the press corp the status of testing of the prototype fast breeder reactor (FBR) "Monju" (280,000 kW), which achieved criticality on 5 April 1994. In the half-year since criticality, the variety of tests to prepare for incorporation into the power generation system in April 1995, have been going well.

"Monju" achieved initial criticality with 168 core fuel assemblies loaded. Subsequently, more fuel assemblies were added in five separate loads, and reactor physical testing began after the full load of 198 fuel assemblies was completed on 20 May. "Flow distribution evaluation" is being conducted now, and the reactor physical testing will be completed during November.

With regard to concerns pointed out by some of the news media that fuel assemblies might have to be changed before full-scale operation because delay in achieving initial criticality led to degradation of the plutonium-241 content of the fuel, PNC has expressed the opinion that "Although a final judgment will be made after testing at 40 percent output, we see no need at present for a fuel exchange." Plutonium-241 accounts for about 10 percent of fissile plutonium, and has a short half-life of 14.4 years. This was raised as a problem because the period between fuel preparation and criticality was longer than planned.

Reactor physical testing is an investigation of the qualities of a nuclear fission reaction that is carried out by operating a nuclear reactor at extremely low output to acquire data needed to evaluate power distribution, reactivity values, coefficients of reactivity, flow distribution, and the radiation shielding around the nuclear reactor.

So far, power distribution evaluation tests, which investigate the distribution of generated neutrons in the reactor core, have produced data that virtually matches the design values for both axial and radial distribution. In the test, an assembly for test use in which foil has been inserted is irradiated in the reactor, then the foil is removed in a glove box, and the results are used to evaluate incore power distribution and other core characteristics. Thus far, 12 test assemblies have been used: five for use in the core fuel range, three for the blanket fuel range and four shielding assemblies for test use. The foil is being measured and evaluated now.

Evaluation of reactivity values, for which measurements have been completed, was conducted to investigate fission generation (control) capacity in the reactor. The quick report values from the test were: for the fuel as a whole, the measured value of the multiplication factor, which was 1 at criticality, was 1.03 (design value 1.05); and the measured value for the control rod (main reactor shutdown system) was 0.08 (design value 0.07).

Measurement is scheduled to be carried out for the evaluation of reactivity coefficients, which is used to investigate variation in nuclear fission caused by temperature and flow volume changes. As for the incore flow distribution evaluation, a partial core (108 assemblies in the inner core) evaluation has been completed, which yielded data that virtually matched design values. Outer core measurements are being taken now.

After the reactor physical testing is completed, PNC will service the equipment; from February 1995, it will heat up the system and test and adjust the water/steam and turbine systems; and beginning around April, it will incorporate the equipment into the power generation system and begin 40 percent, 75 percent and 100 percent output tests. The output tests and the performance tests that have been carried out so far will be completed in December, and the system will be put into full operation.

JAERI Presents Conceptual Design for Passive Safety LWR

95FE0156B Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 13 Oct 94 p 2

[FBIS Translated Text]

Once-Through Type SG Adopted for Expandable LWR to Lighten Operation, Maintenance Load

The Japan Atomic Energy Research Institute (JAERI) has compiled a passive safety light water reactor (LWR) concept that came from the idea that a "reactor in a jar" that could be operated very easily would be desirable.

The LWR is called "JPSR," and the design concept is to create the exact amount and temperature of steam desired for extraction, with just the flick of a switch.

In addition, JAERI's plan is to develop this concept into an extremely safe nuclear reactor that will eventually be suitable for use in developing countries by drastically reducing the human operational and maintenance work so that it can be operated without a trained staff with special technical capability. In FY95, JAERI plans to finish the conceptual design and begin the next phase, the detailed design.

JAERI already has a record of developing medium and small reactors, beginning with the development of marine reactors and including the system integrated pressurized water reactor (SPWR), a passive safety reactor.

In the JPSR, "simple and safe handling" in a form that fully utilizes this knowhow was the primary concept. Also, a loop-type structure was adopted so that the reactor's scale could be increased rather than being limited to a medium or small scale.

The most unique feature of this reactor is that output linked to adjustment of the amount of water supplied to the steam generator (SG). JAERI came up with the idea that the safety features of the LWR could be maximized because of both of the following features (1) output goes down when water temperature in the reactor goes up (density/reactivity coefficient is increased) and (2) it is difficult for reaction rate to increase even if output goes down (doppler coefficient is reduced). Then, JAERI adopted a once-through type SG (the small pipes are straight and vertical rather than U-shaped), which it perfected in the development of marine reactors, so that steam volume will be balanced by volume of water supply.

Combining these features made it possible to create a system wherein, when the volume of water supply is reduced, the temperature of the cooling water for the primary system rises, reactor output falls and reaction is stopped safely. The change in volume of cooling water during this process will be absorbed by a large-scale pressurizer.

Additionally, to ensure full use of the reactor's safety features, the method of adjusting output with control rods was adopted instead of adding boric acid or other chemicals. Efforts were made to reduce maintenance work drastically, such as putting the control rod drive equipment in a pressure vessel to eliminate passages and welded areas to the greatest possible extent.

Moreover, other equipment for water supply pools and excess heat removal were made to run on natural power and were also used by systems in daily use, which reduced the probability of their breaking down when they had to be operated.

Ensuring a high degree of safety was the reason for eliminating pumps and other dynamic equipment, emergency diesels and supplementary cooling systems. Maintenance for basic and continued operation of the reactor was rendered unnecessary.

Basically, if equipment such as operation monitoring equipment is excluded, one switch on the control panel is enough to operate the reactor because it can be shut down by natural power and complex manipulations are not required.

At present, basic specifications for a 600,000 kW class reactor include the following.

Fuel: 17X17 fuel assemblies—145

uranium-235 enrichment—4 to 5 percent

total uranium load—67 tons

extracted burnup—from 47,000 to 58,000 MWD/T

uranium enrichment—4 to 5 percent

total uranium load—67 tons

Containment vessel structure: diameter—45 meters; height—78.5 meters.

JAERI To Begin Irradiation Tests Toward Full Pu Burn-Up

95FE0156C Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 6 Oct 94 p 1

[FBIS Translated Text]

99 Percent Pu239 Burnup Possible; JAERI Aims at Direct Disposal of Spent Fuel

In January 1995, the Japan Atomic Energy Research Institute (JAERI), which is conducting research on fuels that will ensure complete burnup of plutonium and direct disposal of spent fuel as stable waste without the need for reprocessing, will use the JRR-3 research reactor and begin irradiation tests using fuel that contains plutonium (Pu) as a follow-on to the cold testing it has conducted thus far. Data has been acquired that shows that it is possible to burn up and annihilate 99 percent of the Pu239 in the fuels using existing light water reactors (LWRs). The research results are being awaited with interest, as this may become one of the effective means for peaceful use of the excess plutonium that will become available due to the dismantling of nuclear weapons.

The research being conducted by JAERI is on the development of plutonium fuel (stabilized plutonium fuel) whose composition and crystalline structure is like a chemically stable natural mineral (rock) both before and after burnup in a nuclear reactor, and on combustion methods that will ensure its complete burnup. Almost all the plutonium can be burned up and it would be difficult to convert the spent fuel to nuclear weapons because over 60 percent of the plutonium content is non-fissile plutonium such as Pu240 and Pu242. Reprocessing also would be extremely difficult because it is nearly as stable as natural ore. Furthermore, its weathering stability is high and disposal as waste is possible without further

processing. Another feature is that it can be manufactured easily in existing fuel fabrication plants.

In cold testing conducted thus far, JAERI found that two varieties of fluorite type oxide fuels, (1) thoria-base (plutonium, thorium, aluminum and magnesium) and (2) zirconia-base (plutonium, zirconium, aluminum and magnesium), are promising as fuels with irradiation stability and the solid solubility and stability of fission products. Both are chemically stable, and in nature, they come from the fluorite-base compounds corundum and spinel, which are similar to minerals known by the names of thorianite and zircolite. The void coefficient of the thoria-base fuel is negative, but for the zirconia-base fuel it is zero or positive. It is also known that the LWR is better than a fast reactor or a gas cooled reactor for increasing plutonium burnup with these fuels.

Irradiation in the JRR-3, which is to start in January 1995, will take about half a year, then after cooling for a half year, research on the fuel feasibility, fuel characteristics, and core design conditions, etc., will be conducted in a hot testing facility. Plutonium is purchased from the Harwell [phonetic spelling] nuclear research institute in Great Britain, and several hundred milligrams will be used in the tests, which are programmed for three to five years.

JAERI maintains that this research is superior from the viewpoint of non-proliferation, economic merit and safety, and believes that it will contribute to processing and disposal of plutonium from dismantled nuclear weapons and the peaceful use of nuclear energy, and that it can be applied to once-through fuel processing of uranium-235 from dismantled nuclear weapons. Especially with regard to the peaceful use of plutonium from dismantled nuclear weapons, however, the United States is actively studying proposals such as U.S.-Russian joint development of a high-temperature gas reactor and burnup in a high-speed metallic fuel reactor, so some delicate decisions must be made in order to get JAERI's research results applied in this field. Quick results from this research are needed so that Japan can provide positive technological cooperation in this field.

Receiving Drill Conducted for High Level Waste From France

95FE0156D Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 6 Oct 94 p 4

[FBIS Translated Text]

First Public Showing of Special Transport Ship; Waste Receiving Facility Construction To Be Completed February 1995

On 26 and 27 October, the Japan Nuclear Fuel Company and the Nuclear Fuel Transport Company held a drill at Mutsu Okawara Harbor, Aomori Prefecture, for receiving high-level radioactive waste (HLW; in vitrified form), which is to be returned to Japan from COGEMA of France next spring.

The first shipment of returned vitrified HLW will consist of 28 canisters. These will be packed into one cask and carried by a special transport ship.

During the drill, the Pacific Sandpiper (PS; 3,000 ton class), one of the ships being considered for transporting the vitrified HLW, entered port and was open to the news media and relevant parties. A practice run was conducted, using a real cask, a large-scale 150-ton crane and a special transport vehicle.

The ship that will transport the vitrified HLW will be selected from three of the special ships owned by Pacific Nuclear Transport Limited (PNTL), a subsidiary of British Nuclear Fuels Limited (BNFL). The Pacific Sandpiper had come to Japan on other business, and was rushed to the port for this drill.

At the start, the ship was shown to the media by K. Young, the ship's captain. The Pacific Sandpiper was built in 1985, and is about 140 meters long and 15 meters across at its widest point. It is run by a crew of 20 to 30. It was designed as an exclusive transporter of vitrified HLW canisters and spent fuel. It has a dual engine and steering system and is equipped with small screws (bar thrusters) to enable lateral movement. It has the enhanced safety features of double hull construction, computerized collision prevention equipment and the capability to pinpoint current location by satellite. It is also equipped to receive weather maps by fax from weather centers all over the world, and other features of a safety design that meets International Atomic Energy Agency (IAEA) safety standards. It can carry up to 10 casks. Captain Young says, "I am confident that the voyage will be 100 percent safe." The voyage from Le Havre, France, will take one and a half to two months. Captain Young's impression of Mutsu Okawara Harbor is that "It is a spacious, very safe harbor."

The cask, into which the vitrified HLW canisters will be packed, is called Type TN28VT, and two of these were made in Japan in conformity with IAEA Type B container regulations. The cask will carry 28 cylindrical canisters of vitrified HLW, which will be packed in four layers of seven canisters each. Because the cask will weigh about 120 tons when loaded with the vitrified HLW, a large-scale 150-ton crane will be used to move the cask at wharf-side. Although the cask becomes hot due to the heat generated by the vitrified HLW inside, it is normally kept below about 85°C during moves. In terms of safety standards, however, the cask has been designed to ensure safety even when under direct sunlight or other conditions of about 100°C.

A special transport vehicle will carry the vitrified HLW from Mutsu Okawara Harbor. It is a 6-axle, 48-wheel vehicle, and boasts a maximum load capacity of 135 tons. Dual circuit brakes and other safety and operability

features have been considered for driving under winter storm conditions. It is about 12 meters long, about 3.2 meters wide, and about 1.8 meters high. It has about 430 horsepower and a maximum speed of about 25 kilometers (when loaded). Its ascending capability is about 4.5°. It is under lease from Nippon Express, and has been placed at Mutsu Okawara Harbor for the present.

Construction of the HLW management facility that will receive the vitrified HLW was about 90 percent complete as of the end of August 1994, and work is proceeding at a feverish pace to reach completion by February 1995.

The facility will have 160 storage tubes and each will hold nine vitrified HLW canisters, for a total storage capacity of 1,440 canisters. These vitrified HLW canisters will be deposited here under natural air cooling for about 30 to 50 years, then taken to a final disposal site.

Electrochemical Lab, AIST, Develops New Fine Processing Technology Using STM

95FE0023A Tokyo SEMICONDUCTOR WORLD in Japanese No 9, Sep 94 pp 26-27

[FBIS Translated Text] The Electrochemical Laboratory, a national research lab operated by the Agency of Industrial Science and Technology (AIST), has developed an electronic device using a scanning tunneling microscope (STM).

The laboratory has been doing research since some time ago using STMs to perform microprocessing processes, but this time it succeeded in using the STM to form an 18nm titanium oxide pattern on an insulating GaAs substrate. By causing local oxidation of titanium metal with the STM, it successfully formed a longitudinal microstructure wherein an improved quantum effect was desired. Using this same technology, it also succeeded in fabricating a planar-type MIM (metal-insulator-metal) diode. The lab said that these developments have significantly pushed forward the development of elements that function at the quantum level.

Formation of 18nm Titanium Oxide Pattern

First, a 4nm thick titanium film is formed on a GaAs substrate using the vacuum deposition method. Next, a platinum STM needle is brought close to the titanium film and a 5V tunneling bias is imparted and tunneling current is set at 0.8nA. Following that, the titanium oxide pattern is formed by sweeping the needle at a constant speed.

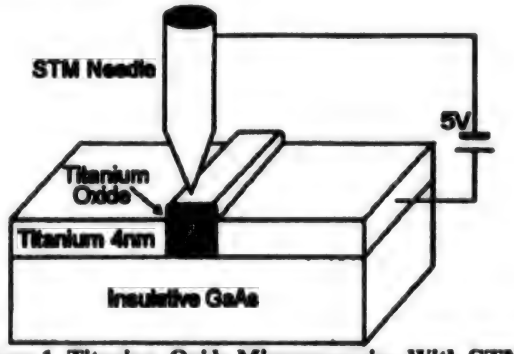


Figure 1. Titanium Oxide Microprocessing With STM

The line width of the titanium oxide pattern varies according to the scanning speed of the STM needle. As scanning speed slows down, the line width gets narrower because there is a decrease in the amount of current per constant length and a decrease in the amount of titanium oxide produced by electrochemical reaction. This enables a line width of 18-20nm to be formed which is less than half that of conventional methods. The width and height of the line is reduced by decreasing the tunneling bias that is imparted. When the tunneling current and scanning speed of the needle are set at a constant 1nA and 0.01μ/sec, respectively, and bias is reduced from 5V to 2V, it reduces both line width and height, with height being reduced by 75 percent from 4nm to 1nm. After an examination to see how far the titanium oxide pattern had penetrated the titanium film, it was found that the pattern had attained a depth of 5nm.

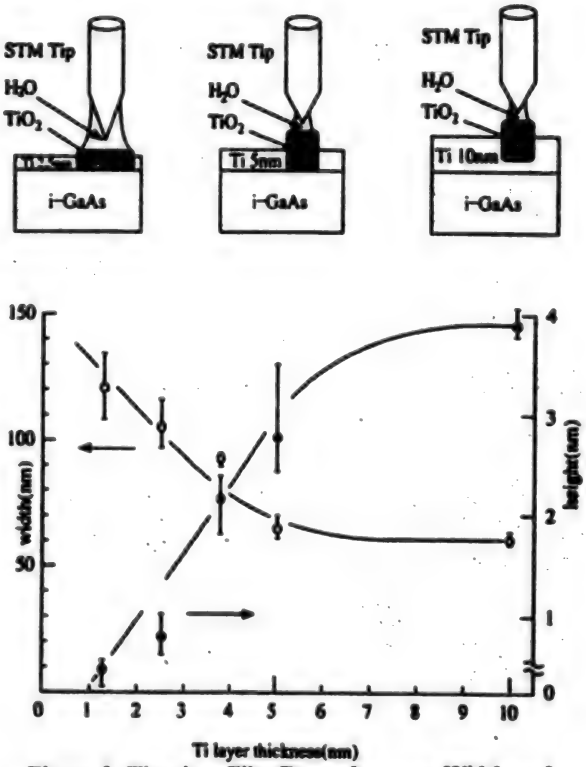


Figure 2. Titanium Film Dependency on Width and Height of Titanium Oxide Pattern Formed

Planar-Type MIM Diode Successfully Fabricated

The laboratory also used the same technology to fabricate a planar-type MIM diode.

The method used was to form a source and drain ohmic electrode on each end of a titanium film measuring 2μ x 4μ x 4μ, and using the STM form a titanium oxide pattern at the center of the titanium film. The titanium oxide pattern that is formed is a high-resistance insulator. The titanium film is 4nm thick, so the titanium oxide pattern reaches the bottom of the titanium film. As a result, the current that flows within the titanium film from the source toward the drain either tunnels into the titanium oxide pattern or jumps the energy barrier. What results is a planar-type MIM diode with a current-voltage characteristic showing a large non-linear characteristic.

An investigation into the temperature dependency of the planar-type MIM diode on the current-voltage characteristic revealed that the energy barrier of the titanium

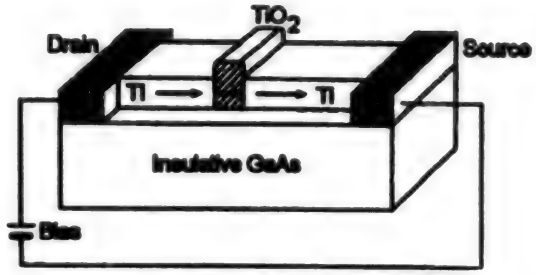


Figure 3. Planar-Type MIM Diode

oxide pattern will jump from 1V to 0.25eV when heat-excited current is dominant in a high temperature region (1000/T=3.5-6). It also revealed that when 10V is imparted it causes a decrease in the energy barrier due to the field, and causes the energy barrier to drop to 0.19eV. This tendency is even more pronounced in low temperature regions. This is due to the fact that in low temperature regions there is an increase in electrons that jump the energy barrier of the titanium oxide pattern with thermal excitation, and also an increase in tunneling electrons.

Electrochemical Lab, AIST, Uses New Quantum-Effect Technology to Analyze Defects in Semiconductor Compounds

95FE0023B Tokyo SEMICONDUCTOR WORLD in Japanese No 9, Sep 94 pp 28-29

[FBIS Translated Text] The Electrochemical Laboratory, a national research lab operated by the Agency of Industrial Science and Technology (AIST), has elucidated the mechanism by which an AlGaAs/GaAs heterojunction structure of the type used by quantum-effect devices is damaged by electron beam irradiation.

Quantum-effect devices are being looked upon as the next wave in semiconductor devices. At present, AlGaAs/GaAs heterostructures with high-mobility 2DEG (2-dimensional electron gas) areas are often used as the crystal structure of quantum-effect devices. Electron beam delineation is the lithographic method used to form such structures, but it has been reported that beam irradiation causes a deterioration of the 2DEG electrical characteristics. This research was conducted in order to elucidate this phenomenon and develop a process by which this phenomenon did not occur.

In Figure 1, we show a drawing of the crystal structure actually used. The 2DEG mobility and electron density prior to beam irradiation were approximately 2 x $10^5 cm^2/V \cdot s$ and 3.4 x $10^{11}/cm^2$, respectively (temperature: 14K). The beam irradiation was conducted at both low temperature and room temperature.

In the experiment conducted at room temperature, researchers projected an electron beam having an irradiating power of 8keV and a current density of about 2 $\mu A/cm^2$. Researchers found that 2DEG mobility starts to

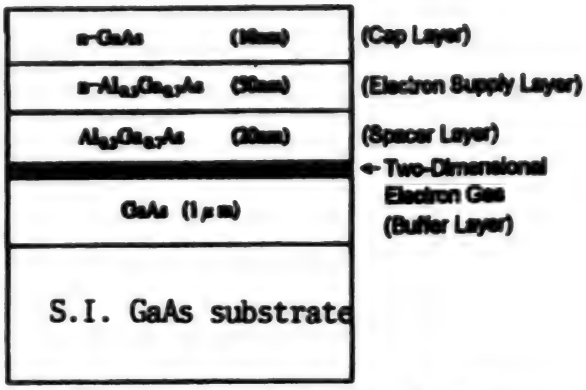


Figure 1. AlGaAs/GaAs Heterojunction Structure

decrease when the electron dosage reaches $1x10^{15}/cm^2$, and falls by 95 percent when it reaches $1x10^{17}/cm^2$. The electron density at this time is also reduced 40 percent. The irradiation dosage of the electron beam used for electron beam delineation is about $1x10^{16}/cm^2$, which is large enough to cause a reduction in 2DEG mobility. This is due to the fact that short-range scatterers are produced near the heterointerface with the increase in ionized scatterers that cause 2DEG mobility to drop.

In the experiment conducted at low temperature, researchers at the lab measured the holes at that location. In order to compensate for variations in mobility caused by changes in electron density when measuring the holes, researchers maintained a constant electron density by light irradiation. In a room temperature irradiation experiment done for comparative purposes, researchers measured the holes before and after irradiation at a temperature of 90K. Researchers found that among the scatterers generated at room temperature, 42 percent were also generated at low temperature. From this, it was determined that two types of scatterers were being produced by electron beam irradiation, namely, those scatterers generated by electron beam excitation at low temperatures and those generated by thermal excitation.

Researchers then investigated the characteristics pertaining to restoring the areas damaged by electron beam irradiation in which both room temperature and low temperature samples were annealed for 15 minutes each. The results of that investigation are shown in Figure 2.

It has been known that in damage to GaAs caused by electron beam irradiation, that a Frenkel defect (vacancy of As atom) is produced by the scattering of energy-electrons in high-energy irradiation of 1MeV or so. This defect is completely eliminated if annealed at 250°C for a few minutes.

In contrast, when GaAs is irradiated with a relatively low-energy electron beam, a defect is produced which is not completely eliminated by annealing at 250°C. The defect which is not eliminated at 250°C is not the same as a Frenkel defect due to the relatively low-energy

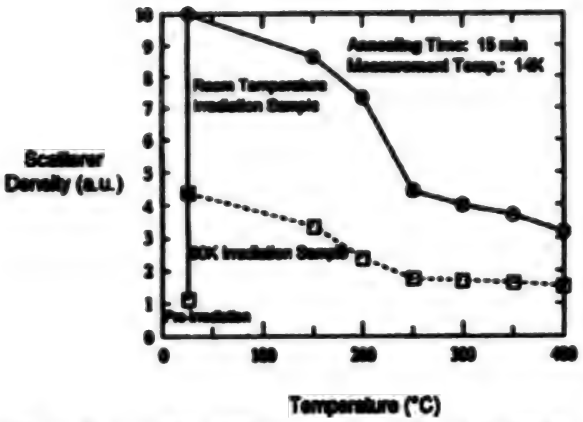


Figure 2. Annealing Effect on Electron Beam Radiation Damage

electron beam, but it is believed that the vacancy of As atoms plays a part in both types of defects.

According to this, it is thought that at least two types of defects are produced during electron beam irradiation at room temperature. Of these, it is possible that the vacancy of As atoms plays a part in the defects produced by low-temperature irradiation, but these are eliminated by annealing at 250°C. The other type of defect, on the other hand, is not produced by low-temperature irradiation but rather by thermal excitation, and is thought to be eliminated with annealing at 250°C.

An experiment was conducted on the areas damaged by electron beam radiation to ascertain the depth distribution of the energy loss of incoming electrons. It was found that when an 8keV beam was used, which produces the largest reduction in 2DEG mobility, that more incoming electron energy was lost within the deep GaAs buffer layer than in the 2DEG region. Scattering was also found to be taking place frequently in the area near the 2DEG region. This is believed to be caused by the formation of short-range electron scatterers such as Al atoms that migrate and form interfacial unevenness in the heterointerface.

A summary of the results follows. When a relatively low-energy electron beam irradiates an AlGaAs/GaAs heterostructure, two types of defects are formed, which cause a deterioration of 2DEG electrical characteristics. The first of these defects is one in which As atom vacancy causes the excitation of the inner shell electron of the As atom in the GaAs buffer layer, and the other defect is one in which short-range electron scatterers are formed near the AlGaAs/GaAs heterointerface.

The former, which was caused by irradiation of the electron beam at low temperature, can almost be completely eliminated by annealing at 250°C. The latter of these defects, which was produced by thermal excitation, is barely restorable by annealing at 250°C. Accordingly, when a structure is irradiated by electron beam, it causes an orbit of ionized scatterers to form within the buffer layer, and being scattered unevenly in the heterointerface, it reduces mobility.

Hitachi Makes Prototype Superconducting Data Processor

95P60115A Tokyo NIKKEI SANGYO SHIMBUN in Japanese 10 Feb 95 p 5

[FBIS Translated Text]

Useful for High Speed Image Processing

Hitachi, Ltd. has produced a prototype superconducting data processor which allows direct input of optical signals. This development is highly promising for high speed image processing. The new processor converts images sent through optical fibers into electric signals using a photo detector made of superconducting thin film. They then are processed at high speed in a Josephson circuit which operates on direct current. It is the first system in which optical signals are processed by a superconducting device. It is expected to be applied in ultra high speed exchange and image processing computers which can meet the demands of the multimedia age.

Hitachi has confirmed the transfer in the following series: optical input - superconducting photo detection - analog and digital conversion through a Josephson circuit - optical output through a semiconductor laser. Real-time input and output of data using 1.3 micron wave length light for communications was confirmed.

Separately, Hitachi has also produced a prototype digital signal processor of 4,292 gate through a niobium (Nb) based Josephson device which operates at the temperature of liquid helium (-269°C). Hitachi has developed the means to build an overall system by combining it with a photo detecting system.

The most crucial superconducting photo detector employs the magnetic flux generated around a thin film through light energy when the light was shone on a Nb nitride thin film 5-10 nanometers thick. It can sense the strength of light caused by the change in analog electric signals that result from interaction of the magnetic flux and the current which passes the device. The prototype system used zigzag superconducting thin film to attain its level of efficiency.

In addition, the electric signal received after conversion from light was converted to direct current which passed through the semiconductor laser and successfully put out an optical signal.

The special feature of the digital signal processor is its ability to operate on DC power.

Compared to currently available alternating current power systems, the power equipment of the new processor can be compact as well as generate little noise in nearby wiring, thus improving performance. It achieved an operating speed of 10 picoseconds (1 pico equals 1/1 trillion seconds), a world record.

This research was conducted under a loan from the Japan Key Technology Center which is administered by both the Ministry of International Trade and Industry and the Ministry of Posts and Telecommunications. When the newly developed elemental technologies are combined, performance of the exchange is expected to improve by 100 to 1000 times over that of the highest speed (about 200 Hz) currently available.

Currently available semiconductors' devices are considered inadequate for the heavy demands for data exchange and image processing entailed in the transmission of the huge amounts of image information during the multimedia age, increasing expectations for ultra high speed superconducting devices.

National Lab Discovers Many Oxide Superconductors

95P60115B Tokyo NIKKAN KOGYO SHIMBUN in Japanese 3 Feb 95 p 6

[FBIS Translated Text]

Critical Temperature Exceeds 100k

The Multicore Project Research Group under the National Institute for Research in Inorganic Materials (NIRIM, Director Kichizo Inomata) of the Science and Technology Agency (STA) has discovered many new oxide superconductors with critical temperatures surpassing 100k (-173°C) in an ultra high pressure atmosphere. A series of discoveries includes five different systems: carbonate, sulfate, barium, aluminum, and gallium. Among carbonate-based oxide superconductors, some show critical temperatures above 117k. This discovery will pave the way for new research efforts on oxide superconductors and is of great interest.

Opens Up New Research

The newly discovered superconductors were all synthesized in an ultra high pressure atmosphere of 5-6 billion pascals (about 1000 hecto pascal atmospheric pressure) and above the melting point of 1200-1300°C. The superconducting critical temperatures of the newly synthesized superconductors included 117k for carbonate, 60-100k for sulfate, 110k for barrium, 110k for aluminum, and 107k for gallium. The newly developed materials can be handled in the same manner as conventional oxide superconductors and commercialization also is possible.

The research group said the reason that various oxide superconductors are synthesized under ultra high pressure is a "subject for future research." However, they explained that "the new materials were synthesized in an ultra high pressure atmosphere by using materials which

are stable under normal pressure." This new method may attract considerable attention while searching for more new materials. Furthermore, it is possible to create new materials superior to the oxide superconductors which have been synthesized under normal pressure for research in the past. "It is not impossible to synthesize new materials with critical temperatures higher than those of mercury and thallium," according to the research group.

Much attention has been paid to oxide superconductors since the discovery of yttrium-based and bismuth-based oxide superconductors. Recently, however, the search for more new materials has been stalemated and research activities on oxide superconductors has been somewhat reduced. Therefore, the NIRIM research group's latest achievements will likely prove significant and may trigger another oxide superconductor boom.

Latest Weather Satellite To Measure Water Vapor, Record Sea Temperature

43070026A Tokyo THE NIKKEI WEEKLY in English 16 Jan 95 p 11

[FBIS Transcribed Text] Japan plans to launch its fifth geostationary meteorological satellite in February to take over the job of observing cloud distributions from the Himawari-4, which has been transmitting since 1989.

The new satellite, GMS-5, will be equipped with two sensors that can observe atmospheric flow patterns and measure the volume of water vapor 5,000 meters above the surface of the earth, as well as provide precise sea-water temperatures.

In preparation for the satellite changeover, and in order to promote more effective use of the observation data, Japan's Meteorological Agency is putting together software and training materials that will process data transmitted from the new satellite.

The agency initially forwarded a prospectus outlining the types of data that the new satellite will transmit, but on request from weather specialists in these countries, it then also put together a user survey and a general explanation of the satellite.

The technology will be supplied to 10 Asian nations and regions.

Installation of Fiber Optic Networks in Kobe Area Ahead of Schedule

95P60110A Tokyo KAGAKU KOGYO NIPPO in Japanese 9 Feb 95 p 1

[FBIS Translated Text]

NTT To Invest ¥80 Billion

President Kojima of Nippon Telegraph and Telephone Corporation (NTT) announced on 8 February at a regular press conference that NTT will put their fiber optic program ahead of schedule to promote disaster measures including underground installation of fiber optic cables and dispersion of communications equipment in order to help reconstruct the Osaka/Kobe area. This includes Kobe City and Nishinomiya City where damage done by the Great Hanshin Earthquake was most severe. A total cost of the operation including quake repair work and installation of fiber optic cables which NTT is trying to promote is estimated to reach ¥80 billion during the next three to five years.

NTT has a plan to install fiber optic cables nationwide. The original plan was to cover 100 percent of the business district and 30-40 percent of residential areas in Kobe City with fiber optic networks by 1997. However, because of the recent earthquake, President Kojima said, "NTT will start from wherever it is needed most rather than worrying about the original plan," in line with the government's move to rebuild a new town under the reconstruction program. His comments indicated cooperation with the government program.

Specifically, in line with construction plan for new buildings and the renovation plan under the reconstruction program, NTT will install fiber optic cables in the buildings. Furthermore, loop type fiber optic networks will be set up so as to be able to maintain communications even if the cables should be partially cut. The installation is scheduled to expand from the existing 200 kilometer long fiber optic cables to 400 kilometers in Kobe City.

Underground circuits, which proved durable against earthquake, suffering only a 0.03 percent damage rate, will be doubled from the current 180 kilometers. As a result, underground cable installation will rise from 6 percent to 12 percent.

Advantest Develops ATM Exchange Evaluation Device

95P60110B Tokyo NIKKEI SANGYO SHIMBUN in Japanese 3 Feb 95 p 9

[FBIS Translated Text]

Able To Check 2.4 Gigabit Transmission

Advantest, a major electronic instrument manufacturer, has developed an evaluation device for the ATM (asynchronous transfer mode) exchange used in next-generation communications services such as B-ISDN (broad-band integrated services digital network). The new device is capable of checking data loss or delay time during high speed transmission of 2.4 gigabit (1 giga equals 1 billion) per second. The company has been focusing on R&D on next generation measurement technology for the advanced communication market which is expected to expand quickly during the move to the multimedia age. This latest development is one result of their R&D effort. The company will now look into promoting its commercialization.

The Advantest Research Institute (Sendai City), where the next generation measurement technology research has been under way, has developed a prototype evaluation device for ATM exchange. The device is capable of investigating, based on the number of cells (the basic unit of information transmission), the mechanism of the loss of cells or delays by monitoring changes in the amount of information over time. At present the technology is being transferred from the Research Institute to the Project Section. While more improvements are being made on the technology, the company will pursue the possibility of commercialization.

Since ATM communications can handle high efficiency multiplex transmission of a variety of information, including voice and highly vivid moving pictures, they are expected to be in wide use very soon. However, if the traffic (amount of information transmission) gets extremely busy and approaches the transmission

capacity limit, cell loss and increased delay phenomena will occur. Efforts to deal with such problems and to improve the technology are being pursued. In order to establish advanced measurement technology in the multimedia age, the company is conducting research on key devices for electronic instruments in addition to the evaluation device for ATM exchange they have just developed.

Communications Encryption Uses Chaos

95P60110C Tokyo NIKKAN KOGYO SHIMBUN in Japanese 8 Feb 95 p 9

[FBIS Translated Text]

Osaka University Conducts Successful Experiment

Mken Co. and the Electronic Engineering Department of Osaka University's Faculty of Engineering have successfully tested a method of encrypting communications that relies on chaotic synchronous control. Chaotic oscillation achieved perfect encryption of data without requiring astronomical computation. Based on the latest demonstration test, Mken and Osaka University will initiate a joint application research project. New data encryption technology is a prerequisite of the increase in data transmission to and from remote sites in the multimedia age, and the market for it is expected to increase.

Joint Research Project To Start

Before transmitting data, chaotic oscillation is applied to the data through ENON [phonetic] image using the chaotic theory. Then the data is encrypted through modulation. The receiver receives synchronous chaotic oscillation, demodulates and downloads the data. This chaotic oscillation does not oscillate in the same form twice, thus making encryption of the data perfect.

The new method saves time and eliminates complicated processing to achieve perfect encryption, unlike conventional encryption methods which rely on a combination of logic. Also it is possible to provide encryption products at relatively low cost once commercialized. Furthermore, the Mken and Osaka University's method can provide encryption communications through two-way multimedia data such as voice and moving pictures in addition to text. It also can be used to process shopping data which users send from home, and medical data for remote area medical practices.

The shift during the multimedia age from stand-alone operations to transfer of data through networks make cost reduction and perfect data encryption more important.

Mken and Osaka University will soon begin their joint research project on application and experiments on transmission and receipt of data to and from remote sites using chaos theory. They hope to make it commercially available this coming fall.

Kyocera Develops New Device for 2-Way Visual Communications

95FE0088A Tokyo NIKKAN KOGYO SHIMBUN in Japanese 9 Nov 94 p 11

[FBIS Translated Text] Kyocera (Kensuke Ito, president) has developed an image coding device (codec) that will enable two-way visual communication by personal computers (PCs) on integrated services digital networks (ISDNs) or local area networks (LANs), and will soon begin delivering samples to software vendors and others.

Highly integrated chips made it possible to consolidate the device onto one board so that it could be connected directly by a PC slot. Kyocera also expects to slash the price to the ¥300,000-¥400,000 level, and begin mass production at its Ise plant starting in early 1995. At the same time, Kyocera is thinking of getting into the U.S. market, where use of PCs and LANs is widespread, at an early date.

With the popularization of LANs, demand has risen for groupware, which is used when people "talk" via PCs and carry out a job together. The market for teleconferencing systems expanded suddenly in 1994, and there is hope that there will be progress in reducing the size and raising the performance of the codec unit that forms the core of the system so that it will become a tool for realizing a visual communications environment on PCs. Kyocera is a major manufacturer of teleconferencing systems and its work on developing a smaller, low-price codec board was motivated by its efforts to exploit this business information network market.

Kyocera's device operates on IBM PC-ATs and compatible PCs, and works with Windows 3.1. It can be inserted in one slot of the PC-AT, and in conjunction with a LAN board, enables two-way communication between PCs on a LAN. Its image compression method conforms with international standards (ITU-T-H.261).

Kyocera says that there is a big demand in the U.S. market, where the use of PC LANs is widespread, and it plans to sell the device in the United States in early 1995.

Interview With MPT's Telecommunications Council Chairman on NII Project

95FE0088B Tokyo NIKKAN KOGYO SHIMBUN in Japanese 7 Nov 94 p 1

[Interview with Sho Nasu, chairman of MPT's Telecommunications Council]

[FBIS Translated Text]

Clear Vision

[NIKKAN KOGYO SHIMBUN] The Telecommunications Council of the Ministry of Posts and Telecommunications (MPT) has finally compiled its report and the project on completing the information infrastructure has finally begun.

[Nasu] I take this as the emergence of a single clear vision of the so-called Japanese conceptualization of the information superhighway. How the principle of private competition is incorporated in this will be very important for the industrial society of the future, and the ideal can be said to be the improvement of the social foundation by the private sector with support from the government. It is also true, however, that there are pros and cons to multimedia. The pros, such as a ¥123 trillion market in the year 2010 or the creation of 2.43 million jobs, is important, but the problem is what will be done when the whole network of not just optical fiber but also ground waves and satellites is completed. A good system and framework must be drawn up for how to proceed from now. This is what I believe.

Advent of New Services

[NIKKAN KOGYO SHIMBUN] You are also the chairman of the "panel on fusion of communications and broadcasting for the 21st century." What is your outlook on the future?

[Nasu] I have great hopes for fusion services such as telephone through cable television (CATV) and the reverse, video transmission through communication circuits. However, this does not mean a change in the roles of communication between two parties and broadcasting to an unspecified number of parties. Everything will not be fused together. It will be a matter of focusing on what to do about the advent of new services that are in the boundary zone between the two. In terms of systems, user convenience and keeping costs down are important. In any event, legal restrictions that preclude new services and cost increases must be avoided. Furthermore, there needs to be a broad study of such things as privacy, copyrights, and problems involving public order and morals. Essentially, the law and rates will probably be the biggest problems to resolve.

Promotion of Free Competition

[NIKKAN KOGYO SHIMBUN] There is debate on liberalization of voice and other basic services and the division of domestic and international services.

[Nasu] Basically, I think that deregulation must be something that promotes free competition. There is a global trend toward liberalization of basic services, and I understand that there are many examples overseas of one company providing both domestic and international services. Before arguing about business systems, however, I think we should fully discuss the issue of the responsibility that comes with liberalization, which must be shouldered by business.

[NIKKAN KOGYO SHIMBUN] The future of NTT will be studied in FY95.

[Nasu] Because of my activities in the information and communications committee of the Federation of Economic Organizations and investment in the Tokyo Tsushin Network (TTNet), I do have my own opinions. Even in the negotiations concerning the frame relay connection, I think that there are problems that should be resolved separate from the question of its suitability. However, the job of the council chairman is to bring about a consensus, and I want to remain completely neutral on this issue. If I think about what is best for the people and Japan, the conclusion will appear naturally.

Fierce Competition for High Packing Density

95FE0088C Tokyo NIKKEI SANGYO SHIMBUN in Japanese 4 Nov 94 p 5

[FBIS Translated Text] The favored candidates for multimedia storage media are the magneto-optical disk and the phase change optical disk. These media are rewritable, portable, and the best for image storage. Along with the normal strategy of using a narrower laser beam in order to increase storage density, new techniques such as ways to arrange the stored information are coming up all the time, and it is possible that the technology map will change substantially in a few years' time.

Super-Resolution Technology

In late September, the international symposium on magneto-optical storage, which is the forum for presentation of results by researchers who have concentrated on the magneto-optical disk, was held in Tokyo. One of the highlights of the symposium was that many manufacturers fought to present research on magnetic super-resolution technology to read data that is stored with a width that is narrower than a laser beam.

Sony Corporation was the first to present its research. Its device has two-tier construction in which a regenerative layer that loses magnetization at a low temperature is layered on top of the storage layer. In regeneration, the whole regenerative layer is magnetized downward by a strong magnetic field, so that the storage layer is masked.

Next, when the temperature of the regenerative layer is raised by heat from regenerative light, portions of the storage layer that are magnetized upward are copied to the regenerative layer above, so that masking is removed just for those portions. Erroneous pickup of an adjacent storage mark can be prevented, achieving the same effect as narrowing down a laser beam. At the international symposium, Canon Inc., Fujitsu Laboratories and other companies presented super-resolution technology using a three-layered magnetic film. The space between storage marks is the index of the minuteness of the storage, and for all of the devices, it was around 0.4 microns, (1 micron is a thousandth of a millimeter), less than half of existing devices.

Tunnel Effect Used

A revolutionary technology for narrowing beams is the use of a phenomenon called the tunnel effect of light. It uses evanescent light which is created when light is

narrowed to 0.1 microns or less and placed as close as possible to the storage medium.

Hitachi Ltd. succeeded in narrowing light to 0.07 microns, which equates to a tenth of the original wavelength, by using optical fiber and sharpening the tip as much as possible. In these experiments, it succeeded in increasing storage density one hundredfold. Hitachi believes that it can raise the density one thousandfold if it can make the tip of the optical fiber even smaller.

In the case of the magneto-optical disk, the wavelength of the laser light was initially 830 nanometers (1 nanometer is a billionth of a meter), but now it is 780 nanometers. Companies such as Sony and Hitachi have reached agreement to standardize the next-generation product, and a 680 nanometer red laser has been proposed for this product. The next goal is to achieve blue and green lasers at the 500 nanometer level, but even if this is actually used, it is believed that the limits of surface storage density will be reached at around 10 gigabits (1 gigabit is 1 billion bits) per square inch.

Storage by use of evanescent light can be said to be one of the promising technologies for clearing that wall.

Signal Storage in Grooves

There are moves to come up with storage methods from a completely different angle. NEC Corporation has presented a technology for storing signals in guide tracks called grooves in addition to normal storage tracks. This appears to halve the width of the tracks, which increases density. NEC's target is to increase storage density by eightfold.

Hitachi Maxell successfully tested a method of storage on magneto-optical disks that use the four values "0," "1," "2" and "3" instead of the existing method of using the two values "0" and "1" for storage. It used a two-layer construction for the storage layer, which made it possible to divide the laser intensity into four stages. Hitachi Maxwell maintains that this will make it possible to raise density by almost 20 times that of binary storage.

Because the phase change optical disk also uses lasers for storage and regeneration, it has many points in common with the magneto-optical disk. The steps used to increase density, such as the use of a short wavelength laser and doing research on super-resolution technology, also are similar.

Matsushita Electric Industrial Company, which is concentrating on the phase change disk, used an atomic force microscope (AFM) to send a tunnel current and store at a 10 nanometer diameter onto germanium-tin-tellurium alloy, a phase change storage material. The company says that a super-high density of 1 telabit (1 telabit is 1 trillion bits) per square centimeter is possible.

It can be said that storage by microscope is a completely separate technology for reading and writing data without using light. Researchers of hard disks and other forms of magnetic storage also are looking with interest at the technology of storage by microscope as one that is the next step after perpendicular magnetization storage.

It appears that it will take time to discern which technology will win out in the 21st century.

Osaka U. Confirms Time Division Multiplex Transmission Effective

95FE0088D Tokyo NIKKAN KOGYO SHIMBUN in Japanese 11 Nov 94 p 7

[FBIS Translated Text]

Optical Fiber Microcell Wireless Communications

A group headed by Seizo Komaki, an instructor in the Engineering Department of Osaka University, confirmed that an optical switch time division multiplex (TDM) bus type transmission is an effective method for transmission between control station and multiple microcell wireless stations in mobile communications. This is hope for application of optical fiber microcell wireless communications, which is called the mobile communications system of the future. There is concern that rapid innovation in mobile communications technology will bring about a vicious cycle in which investment in the latest communications equipment will have to be made before the cost of investment in control stations which are dedicated to different communications modes has been recovered. It is in this context in which Komaki's group has proposed a "wireless highway" that will use optical fibers to transmit various mobile communications mode signals in integrated form.

In this case, because radio waves are analog signals, the group thought of chopping up the waves to convert them into pulse form so that they can be divided and transmitted, using a router, which is a kind of switching equipment, to direct the pulses, and sending them at high speed.

The group used the optical switch as the chopping tool, devised a method for dividing and transmitting the signals without intermingling with the conversations of other people, and put the system together in TDM bus mode. They tested signal strength because the degree of degradation of signals transmitted in this manner is the deciding factor of whether this kind of communication can be used. It was found that there was less noise than when optical couplers are used for connection. The noise ratio at the tenth and farthest base station was better by 5 decibels. On the basis of these results, Komaki's group judged that the TDM bus type using optical switching was an effective optical fiber microcell wireless communications mode and in the future, they plan to study a method whereby the attenuated portion will be boosted by optical amplifier. These results will be presented at a conference jointly sponsored by the Kansai chapters of academic societies concerning electrical technology, which will be held at Osaka University on 13 November.

JTTAS To Provide Industrial S&T Program in Asia Using Communication Satellite

95FE0088E Tokyo NIKKAN KOGYO SHIMBUN in Japanese 10 Nov 94 p 1

[FBIS Translated Text]

200 Firms To Invest in Broadcasting Company

In early December 1994, a new company will be formed that will provide programs on industrial S&T to 45 Asian countries via communications satellite (CS). It was planned by the Japan Industrial Technology Promotion Association, Inc. (JTTAS; Takehiko Matsuda, chairman), and so far, almost 100 firms, including JTTAS, have announced that they will invest in the new company. Service is scheduled to begin in April 1996, and a preparatory company will start up in March 1995. After that, a two-way service via the Internet also is being planned.

The new company, "Asian High-Tech Shower International Network" (tentative name), will seek capital investment by companies that have branches in Asia and from private universities. It appears that almost 200 firms will invest ¥ 5-10 million each by the time the new company is established. Two parties each will be selected from the companies and the universities as representatives of the founding members. Waseda University and Keio University are candidates to represent the universities.

New shows as well as programs of "High-Tech Shower International," a show that specializes in technology that is being produced in Japan at present by Japan High-Tech Satellite Network (JHS), the association's business firm, will be televised to the Asian countries via JCSAT-3, which is scheduled to be launched in August 1995. The 40-minute shows will be rebroadcasted three times a day, and televised to suit the local time in receiving countries.

Programs produced by JHS that have been shown in Japan already have been sent in videotape form to Hong Kong, Taiwan, South Korea and Singapore, and it is said that at this point, there have been inquiries from countries such as China, Malaysia and Thailand. Also, there are prospects that the program will be provided to countries such as Vietnam, Pakistan and Cambodia through official development assistance (ODA).

Sumitomo Electric To Mass Produce PHS Station's Transmission/Reception Equipment

95FE0088F Tokyo NIKKAN KOGYO SHIMBUN in Japanese 5 Nov 94 p 5

[FBIS Translated Text]

Mass Production on Scale of 5,000 Per Year

Sumitomo Electric Industries Company (Noritaka Kurauchi, president) will begin mass production of transmission/reception equipment that forms the core of base stations for "personal handy telephone systems (PHS)," or, simplified, portable telephones. A manufacturing line will be set up in the Osaka plant (in Osaka City) and production will begin on a scale of 4,000 to 5,000 per year starting in April 1995. This is in preparation for next fall, when commercial PHS service will begin on a full scale. The company's aim is to set up mass production capability in advance and to use the transmission/receiving equipment to develop a superior share of the PHS market, for which high growth can be expected.

Line Set Up in Osaka Plant

Sumitomo Electric's plan calls for the radio and optical systems division of its Osaka manufacturing plant to establish the transmission/reception equipment production technology by the end of 1994, and for the systems promotion division, which is working on LAN (local area network) and traffic control equipment, to start mass production in April 1995. Initial monthly production will be several hundred units, but this will be increased to 1,000 per month by the beginning of fall.

To minimize the burden of investment, efforts will be made to reduce production cost by converting the systems promotion division's electronic equipment line for use in manufacturing the transmission/reception equipment. However, because this equipment will generally be set up outside, it will be fully equipped with instruments for measurement and for confirming reliable functioning, to ensure that there is no hindrance to performance even under harsh environmental conditions.

With regard to the startup of the PHS business, Daini Denden (DDI) already has established a planning company, in which Nippon Telegraph and Telephone (NTT) will participate through a subsidiary. Sumitomo Electric belongs to a "third coalition," which competes with these two firms, and on 8 November, it will form a company called "Astel [phonetic spelling] Kansai Planning" with 11 firms including the Kansai Electric Power Company. Service is scheduled to start from next fall.

It is predicted that PHS will suddenly become popular right before the beginning of commercial service in FY95. Because of weak signal strength, PHS will require the installation of base stations at 400 to 500 meter intervals. It has been estimated by some that over 450,000 base stations nationwide will be needed in five or six years, when the service expands to a national level.

So far, Sumitomo Electric has delivered four sets of test-manufactured transmission/reception equipment for base stations for use in PHS commercialization tests that were carried out in the Kansai area. By announcing that it has built a mass production system, it is making a strong move to get its equipment adopted by Astel. In the future, it plans to go on the offensive and expand its target to the third coalition in regions outside the Kansai area.

JSAT To Launch Fourth Satellite by 1997

95FE0089A Tokyo NIKKAN KOGYO SHIMBUN in Japanese 1 Nov 94 p 11

[FBIS Translated Text]

To Pair Up With JSAT-3

Japan Satellite Systems (JSAT; Michio Sato, president) plans to launch its fourth satellite by 1997. It appears that the satellite will be placed in stationary orbit at 124° east longitude (E), to serve as a supplement to JSAT-3, which will be launched into an orbit at 128°E in August 1995. This will complete JSAT's system for digital broadcasting, which is scheduled to be implemented around the spring of 1996.

Domestic communications satellites (CS) normally are deployed in pairs, in stationary orbits with a difference of 4°, and provide communications and broadcasting services. This system of supplemental satellite pairs is used by JSAT with satellites at 150°E and 154°E, its rival Space Communications (SCC) with satellites at 158°E and 162 °E, and CS-3 (Sakura-3) with satellites at 132°E and 136°E.

JSAT is planning to launch the fourth satellite because a formal decision has been made to deploy JSAT-3 at 128°E in August 1995. JSAT says that it wants to set up a paired system without letting too much time elapse after launching the third satellite. Thus it appears that the fourth satellite will be placed in orbit at 124°E, the slot that had been secured by Satellite Japan (SAJAC), which is under joint management with JSAT.

MPT, EU To Discuss Digital Broadcasting Standardization in April 1995

95FE0089B Tokyo NIKKAN KOGYO SHIMBUN in Japanese 11 Nov 94 p 11

[FBIS Translated Text]

MPT, EU To Meet on Digital Broadcasting

The Ministry of Posts and Telecommunications (MPT) and the European Union (EU) will hold a conference in Tokyo around April 1995, to discuss digital broadcasting.

A basic agreement was reached on this at a Japan-Europe experts' meeting at the end of October 1994, where it was formally decided to work together on standardized methods for digital broadcasting, such as satellite broadcasting and cable television (CATV). MPT also wants Japan and its Asian neighbors, such as South Korea, to keep apace on digitization.

The core participants of the Japan-Europe experts' meeting were members of Japan's Broadcasting Technology Development Association (BTA) and the European digitization group DVB. At the meeting, views were exchanged on realizing digital broadcasting, and it was agreed to continue to meet in the future.

The goal of the Japan-Europe conference will be to discuss a proposal for standardization of digital broadcasting. Therefore, the agreement reached at the experts' meeting also constitutes an agreement of views that Japan and Europe will adopt common standards and build a system for cooperation for digital broadcasting in the future.

Great Britain, Germany and France plan to carry out digitization of satellite broadcasting and CATV from the end of 1995 through 1996. In addition, Star TV broadcasting for Thailand will be digitized in July 1995, and South Korea is planning digital broadcasting from "Koreasat," which will be launched in April 1995. In looking toward television of the future, which will transcend national borders, MPT is aiming at the realization of common digital broadcasting methods with Asian countries as well as the EU. It, therefore, will advocate the creation of unified standards.

JSAT To Operate Communication Satellite Digital Broadcasting

95FE0089C Tokyo NIKKAN KOGYO SHIMBUN in Japanese 11 Nov 94 p 11

[FBIS Translated Text]

New Company Formed to Plan Business Startup

On 10 November 1994, Japan Satellite Systems (JSAT; Michio Sato, president) and the four major trading firms that capitalize it, including Itochu Corporation, formed "DMC Planning," a company to survey the startup of a digital broadcasting business using communications satellites (CS).

The goal is to realize a plan for digital broadcasting through the use of three satellites starting around the spring of 1996, and also to study other possibilities, such as the additional function of digital broadcasting stations.

The new company will begin with ¥100 million in capital. Itochu Corporation, Nissho Iwai Corporation, Mitsui & Company, and Sumitomo Corporation each will provide 23 percent of the capital, and the remaining 8 percent will be provided by JSAT. Hirokazu Yoshimoto, chairman of JSAT, has been appointed as the company's president. The company's base will be in the JSAT main office, located in Toranomon, Tokyo.

JSAT plans to launch its first international satellite, the JCSAT-3, in August 1995, and carry out full-scale digital broadcasting with over 50 channels in the spring of 1996. The new company will work on drafting a proposal for

standardization of satellite digital broadcasting, which is being studied by the Ministry of Posts and Telecommunications, and also will refine concrete operational plans.

CATV Companies Enter Telephone Service

95FE0089D Tokyo NIKKAN KOGYO SHIMBUN in Japanese 25 Nov 94 p 11

[FBIS Translated Text]

Go-Ahead for Entry Given

The Ministry of Posts and Telecommunications (MPT) has drawn up guidelines for cable television (CATV) telephones. According to MPT, this means that "a structure has been completed to allow entry of CATV firms into the telecommunication service market," because these are guidelines for providing telephone services that use CATV networks. Despite the fact that the "go-ahead" has been given for the so-called telecommunications/broadcasting fusion service, it appears that a little more time will be needed for such a service to take hold.

The guidelines drawn up by MPT include the following points:

(1) CATV firms that provide telephone service will be Class I telecommunications enterprises, the same as NTT, et al.

(2) Telephone numbers will be the same as those used in the NTT system.

(3) Connection between CATV networks and NTT or DDI and other new common carriers (NCC) will be in accordance with terms set between the parties concerned.

Request for Third-Party Body Ignored

The guidelines are a compilation of MPT's thinking after a hearing of about 20 firms including CATV enterprises, NTT, et al. A CATV firm that participated in the hearing welcomes the guidelines, saying that "It reflects the CATV side's opinions to a substantial degree. It will be a big conversion in which we will play an active part." MPT explains that "A system has been created for approval of the telephone service. Companies that actually carry out CATV telephone service probably will be created during 1995."

Circuit connection to NTT, et al., will be essential because there are only 100,000 households that can subscribe to CATV. Although the CATV firm says that "Even NTT appears to believe that connection with CATV telephones is inevitable," it is possible that disputes will arise over connection terms when implementing virtual private networks (VPN) and other advanced services. In fact, there was a request from the CATV side during MPT's hearing for the establishment of a third-party body to ensure smooth connection, but this was ignored in the current guidelines.

Incidentally, Great Britain is the only place in the world where CATV telephone service is provided. It began when Nynex and other North American telephone companies started up the CATV telephone service, and many users switched from British Telecom (BT), which had a monopoly over the local telephone network. At present, half of the approximately 600,000 CATV subscribers are using CATV telephones, and it is said that this has dealt a severe blow to BT.

Rejuvenate Regional Systems?

NTT's greatest fear now is that it will follow the same path as BT. The sense of NTT as the only telephone service firm definitely will wane if a number of CATV networks are connected in Tokyo and Osaka, then linked by the long-distance networks of NCCs. "CATV telephone services have a big future because they do not have to use NTT." Some NCCs (Japan Telecom Company) have come up with this clear status for CATV telephones.

"To win from NTT, installation and rates must be inexpensive," says Tokyo Cable Television. This may be a destabilizing factor for NTT, which decided to raise its basic rate. Also coming up in FY95 is the lifting of the ban on connection of leased lines and public access lines for voice line services, and it does not appear that an effect on the long-distance sector can be avoided.

Some concerned parties have even pointed out that "It may be MPT's aim to use the CATV telephone service to rejuvenate the regional systems sector, which is monopolized by NTT."

Hitachi Develops Next Generation Digital Video Disk

95FE0089E Tokyo NIHON KEIZAI SHIMBUN in Japanese 29 Nov 94 p 11

[FBIS Translated Text]

Full-Scale Competition Toward Standardization

On 28 November, Hitachi, Ltd. and Nippon Columbia announced the joint technological development and trial manufacturing of a next-generation digital video disk (DVD) that can reproduce motion pictures (maximum length 135 minutes) with high resolution, using a disk of the same size (12 centimeters in diameter) as an audio compact disk (CD). The two companies combined their technologies to record and reproduce with high resolution one motion picture tape onto one disk. All the AV (audio-visual) equipment manufacturers have been working to develop next-generation DVDs, and the participation of Hitachi and Columbia has created prospects for full-scale competition toward standardization.

Hitachi's technology is a "variable transfer rate system." Hitachi applied for the patent in 1988, and acquired a basic patent in Great Britain and the United States. This system varies compression ratio in accordance with the

complexity of the image, which improves picture quality. When combined with Nippon Columbia's optical disk technology, reproduction of optical disks with a high density four times that of existing video CDs was made possible.

This made it possible to record a maximum of 135 minutes of motion pictures at MPEG level 2, an international standard for high-resolution motion picture compression. The maximum transfer rate is 10 megabits (10 million bits) of image and audio data per second.

Imaging media using optical disks, such as video CDs that conform to the MPEG 1 international standard, already have been produced commercially, but they can only record up to 74 minutes of motion pictures and also leave room for improvement—for example, the reproduction of rapid movement is unnatural. That is why Matsushita Electric Industrial Company, Sony Corporation, Toshiba Corporation, Pioneer Electronic Corporation, Sanyo Electric Company, et al., have been working independently on developing next-generation DVDs to replace videotape as the image recording medium for the multimedia age.

These companies want to achieve this goal around 1996, but standardization of specifications is essential in order to do that. It is expected that henceforth, moves toward standardization of specifications will begin in earnest among the relevant manufacturers, and that debate will be spurred on by the participation of Hitachi and Nippon Columbia, which have their own "variable transfer rate" technology.

Status of Work on DVDs by Various Companies

Victor Company of Japan: Using an independent "variable transfer rate" technology, Victor has achieved the stage of practical use with technology that enables recording of 135 minutes of motion pictures on one disk. Amount of data that can be transferred in 1 second is an average of 3 megabits and a maximum of 6 megabits.

Pioneer: Pioneer has developed its own specifications to process the same amount of image information as the next-generation DVDs that have been test-manufactured by Victor Company, et al., at twice the speed. Transfer rate is fixed and image processing is at a fixed compression ratio. Amount of data that can be transferred in 1 second is 6 megabits.

Sanyo: Combining its new development of an optical disk with four times the density of a video CD and a red semiconductor laser with the extremely short wavelength of 635 nanometers (1 nano is one billionth), Sanyo can record and reproduce 135 minutes of imaging on a disk that is 12 centimeters in diameter. Data transfer is at a fixed rate of 3 megabits per second.

Toshiba: Toshiba developed a digital image compression technology for DVDs and bidirectional CATV (cable television), and ordered two sets from its partner, Time Warner in the United States. Uses variable transfer method with average rate of 4 megabits per second.

(Note: Companies whose DVD specifications are not clear were excluded from this list.)

Fujitsu Develops World's Smallest Broadband SAW Filter

95FE0089F Tokyo KAGAKU KOGYO NIPPO in Japanese 25 Nov 94 p 7

[FBIS Translated Text]

Will Handle Quasi-Microwave Band

Fujitsu and Fujitsu Research Institute have co-developed the world's smallest broadband SAW filter. It will handle the quasi-microwave band (1.7 - 2.5 gigahertz), and starting February 1995, Fujitsu will send out samples under the "F6 series" product name. This is the first SAW filter for use in the quasi-microwave band, and its maximum broadband capability is 100 megahertz. It will be used in terminals for wireless LANs and next-generation digital cordless telephones in Europe and the United States.

The SAW filter is a device that uses surface acoustic waves, which are propagated by gathering energy near the surface of a piezoelectric substrate made of materials such as lithium tantalate monocrystals, to allow passage of specific frequencies. Fujitsu has a 70 percent share of the global market of SAW filters used in portable telephones.

Fujitsu used the latest processing technology to try to reduce the size of SAW filters by 50 percent, and came up with the world's smallest (3mm long, 3mm wide and 1.25mm thick). It is resistant to weather and mechanical vibration. Also, external matching circuits have become unnecessary because of the realization of low insertion loss and a 50 ohm passband impedence. Sample price is ¥1,000. Mass production of 200,000 per month by the end of April 1995, is planned.

FSX Survives Co-Development Phase Fights

43070029A Tokyo THE NIKKEI WEEKLY in English 16 Jan 95 pp 1, 23

[Article by Fumio Sumiya and Lauren Fredman, staff writers]

[FBIS Transcribed Text] The FSX, the next-generation jet support fighter for Japan's Self-Defense Forces, has seen more battles than most military aircraft—though the fighting has been confined to the negotiating table, not the skies.

Japan's plan to develop the aircraft by itself in the late 1980s instead of buying a U.S. model off the shelf triggered one of the most divisive trade brawls ever between Tokyo and Washington. The dispute was only resolved when Tokyo agreed to co-develop the aircraft with the Americans.

Now that the co-development has been completed, however, Japanese industry officials are already bracing for the next battle—the production stage. Japan and the United States have entered negotiations on mass-producing the fighter.

Japanese contractors controlled 60 percent of the development work, and "we want to set aside a large percentage of the mass production for them, but we predict the United States will try to increase its share," said Yutaka Hineno, managing director of aerospace and special vehicles at Mitsubishi Heavy Industries, Ltd., the prime contractor that last week unveiled a prototype of the FSX.

As if to justify that concern, John Richards, a deputy assistant secretary of commerce, said, "We've always viewed the production phase of the program as the part that would provide the greatest economic benefit to the United States."

Despite the fears expressed by company executives, Mitsubishi Heavy President Kentaro Aikawa lauded the FSX at the roll-out ceremony of the prototype held at the company's Nagoya factory as "the first big cooperation project between Japan and the U.S. defense industries."

The Japanese and U.S. governments plan to launch the first trial flight of the FSX this summer and to start mass production in fiscal 1996. The governments are expected to start talks on mass production soon.

At issue is not only who will produce what, but also how many jets will be manufactured.

Washington has unofficially informed Tokyo of its intention to produce up to 130 planes, but Tokyo believes that number is too high considering the steady decline in defense spending here with the end of the Cold War.

The Japanese government initially planned to deploy 25 FSXs in each of the Air Self-Defense Force's three flying corps. The total number of FSXs needed was estimated at 120-130, including for reserve and training use.

But since the international defense situation has completely changed in the past six years, Japan's defense budget for fiscal 1995 was reduced by 6.5 percent from the previous year.

The Air Self-Defense Force now has 170 F-15 main fighters, and 74 F-1s. A panel for the defense policy last fall advised a reduction in the number of jet fighters.

"We cannot expect a large increase in defense spending after fiscal 1996. Then it will be possible to deploy only 18 FSXs for each flying corps, and 70-80 planes in total. That's the limit," said a Defense Agency official.

Such a controversy seems almost natural for a jet fighter that was born amid discord.

Co-Development Battles

The Japanese government initially intended to develop the support fighter solely through the nation's aerospace industry. But after relentless pressure from Washington, the two agreed in November 1988 to co-develop the FSX with the American defense industry as a successor to the F-1 fighter, the existing Japanese support fighter.

Tokyo had initially budgeted ¥165 billion for the development of the FSX, but that swelled to ¥327 billion.

"We could create a next-generation fighter with only our own technology," said an official of a company that took part in the project. "We didn't need any help from the United States on development and production technology. But Japan depends on the U.S. security system, so I guess the government couldn't refuse."

Some Americans were concerned that the U.S. would once again be transferring technology to Japan without getting much in return. Worse, the United States would be helping set up a rival in the aircraft industry, considered at the time an industry that Japan hadn't yet "taken over."

The two countries decided the FSX would be a modified F-16. The U.S. contractors led by Lockheed Fort Worth Co., were allocated a 40 percent share of the development work. And it was agreed that any technology that emerged from the project that was based on U.S. technology would be available to the U.S. firms for free.

The FSX adapted state-of-the-art technology such as active phased array radar and co-cured composite wing structure. Indeed, radar developed by Mitsubishi Electric Corp. has already been received by the U.S. Air Force. It is said to have influenced the F-22, the U.S.'s newest fighter.

"There was no conflict on technology transfer between Japanese and U.S. companies. We have created a tight, credible relationship," said an executive of a Japanese company involved in the project.

In spite of the Japanese fears, U.S. officials said it is possible an FSX production agreement could be obtained by Congress without the kind of controversy caused by the development agreement.

"The view in the United States has changed. Japan is no longer seen as an unstoppable juggernaut that is gobbling up U.S. industries," said Edwin Hind, vice president of International Technology and Trade Associates Inc., which advises company on trade matters.

Added Rust Deming, minister of the U.S. Embassy in Tokyo: "Defense spending in the United States and Japan is continuing to decrease. The FSX project proved that co-development can save costs. It will intensify the relationship between the two countries as allies. We expect that the U.S. defense industry will participate not only in the mass production of the FSX but also future projects."

Sky Wars Next?

Setting aside concern about the FSX, Japanese defense industry sources said the next target will be the Theater Missile Defense system, a defense strategy against ballistic missiles backed by satellites.

"We feel the necessity to cooperate again in the future," said Hineno. "We learned how to co-develop from the FSX project."

Cooperation on the Theater Missile Defense could also bring problems—but with China, not the United States.

Beijing has voiced dissatisfaction with moves by Japan and the United States regarding development of the system. A Chinese defense official said the system would disturb the Asia-Pacific regional situation.

MELCO Suggests JDA Use "XAAM-4" Missile On Board F-15

95P60109A Tokyo NIKKAN KOGYO SHIMBUN in Japanese 8 Feb 95 p 1

[FBIS Translated Text]

Air-To-Air Missile Under Development

Mitsubishi Electric Corporation (MELCO) (President Takashi Kitaoka) disclosed on 7 February that MELCO proposed that the Japan Defense Agency (JDA) install the "XAAM-4" air-to-air interception missile, which is being developed by MELCO, on the main fighter "F-15" (U.S. made) in the future. JDA is currently proceeding with plans to modify the F-15 to upgrade its performance. Agreement between the U.S. and Japan on cooperation in possible modifications to improve the F-15 performance is expected at the "Joint U.S.-Japan Defense Development and Systems and Technology Forum." Discussion of the F-15 performance modification is expected to begin officially after April. MELCO's latest proposal reflected such movement. In line with MELCO's proposal, U.S. companies, including Hughes Aircraft and Raytheon, are expected to surely propose using missiles which they have already developed under the F-15 modification plan in Japan. The decision by the JDA is anticipated with great interest.

JDA started procuring the F-15 in FY80. They have decided to look into plans to modify the F-15 because it will be very costly to develop new aircraft to succeed the F-15. Yet if they use the F-15 continuously for over 10 years its equipment configuration will become outdated, necessitating the installation of new equipment. Modifications will include new electronic equipment and a stealth configuration which makes radar detection more difficult, as well as a new onboard missile.

The XAAM-4 under development by MELCO is meant to stand up to enemy fighter aircraft and air-to-ship missiles. It is a successor to the currently available "AIM-7" air-to-air missile. JDA has allocated ¥4 billion in FY94 for R&D and ¥12 billion in FY95.

The AIM uses the semi-active method in which target reflection waves are detected and tracked through special electromagnetic waves which are emitted from something other than the missile (combat carrier aircraft). The new missiles will use the active method in which electromagnetic waves are emitted by the missile itself to detect and track the targets. Therefore, the carrier aircraft (fighter aircraft) is able to make an instant getaway to safety as soon as it releases the missile.

MELCO's aim is to develop a missile which will not easily be affected by enemy interception radiowaves while detecting and tracking stealth or small objects which are difficult for radar to detect. JDA will decide on the detailed modification plan before the end of 1996, taking into consideration MELCO's proposal and discussions about F-15 modification plans with their U.S. counterparts.

JDA To Develop Electronic Countermeasures for Fighters

95P60109B Tokyo NIKKAN KOGYO SHIMBUN in Japanese 8 Feb 95 p 13

[FBIS Translated Text]

Early Deployment Planned

The Japan Defense Agency (JDA) will start an R&D program in FY95 for early deployment of injection-type ECM (electric counter measures) equipment for fighter aircraft. This technology has been in the basic research stage since FY90. The ECM equipment aboard fighter aircraft will act as a "decoy," allowing the plane to escape enemy radar detection and missile attack. The U.S. and European industrialized countries have had ECM equipment under consideration but they have not put it to practical use. JDA will allocate ¥700 million for development starting in FY95, targeting FY2000 for deployment. Fujitsu Corporation (President Tadashi Sekizawa), which has been in charge of basic research, is expected to continue its role.

The ECM equipment aboard fighter aircraft in the past "blinded" enemy radar by disabling their detection and communications capabilities with bursts of radiowaves. This technology, however, was superseded by advancements in radiowave and telecommunications technologies that made it possible for those radiowaves to be used to detect and capture the emitting aircraft itself. This development encouraged greater improvements in ECM equipment to assure performance and safety of fighter aircraft.

Injection-type ECM equipment can function as a pseudo flying object. It can detect enemy radar, and once an enemy missile is launched the ECM equipment is released from the fighter aircraft emitting a radar signal that makes it appear to be the launching aircraft itself. The ECM equipment is composed of thermal cell, transmission and receiving equipment, and antenna that emits radiowaves. The technologies planned for the future development include stable flight capability, wide variety band semiconductors, small volume and high output radiowave capability.

Now that the primary objectives of the basic research stage has been achieved, the project will be upgraded to the development stage to produce simulation equipment and begin R&D for practical application. When completed, it will be able to be installed in the F-15 main fighter aircraft and the FSX next-generation support fighter aircraft, improving Japan's air defense capability.

MELCO To Provide FSX Radar Technology to Westinghouse

95P60109C Tokyo NIKKAN KOGYO SHIMBUN in Japanese 4 Feb 95 p 1

[FBIS Translated Text]

For WH Commercial Use

Mitsubishi Electric Corporation (MELCO) (President Takashi Kitaoka) disclosed that basic agreement has been reached between his company and Westinghouse Electric (WH) of the U.S. for the export of high power amplifiers, a core component in the high performance radar technology which MELCO had developed for the Air Self Defense Force's next generation support fighter, the "FSX." The agreement was reached in response to a request from WH. Specific negotiations are now under way on arrangements to ship samples, technical specifications, and price. They expect to sign the official contract as early as the end of March. WH plans to use the technology it imports for commercial purposes. If all goes well, it will be the first instance of Japanese defense technology being used abroad for commercial purposes.

The new "active phased array radar" technology was developed by MELCO. Conventional radar can detect only those objects traveling in the same direction as that of the radar beams. But the new radar is capable of detecting and simultaneously recognizing objects such as missiles and fighter planes coming in from all directions and of notifying any partners. One special feature of the system is use of gallium arsenide (GaAs) semiconductor devices in place of conventional electronic tubes.

The high-power amplifier is at the core of the new radar whose scanning speed is much faster than that of mechanical scanning antennae. This enables searching, detecting, and tracking of multiple objects. This capability gives it a wide range of commercial applicability.

MELCO agreed to enter negotiations with WH since WH indicated their intention to use the device exclusively for commercial purposes. WH has not disclosed specifically what areas of applications they have in mind. But they are expected to use the high-power amplifiers in combination with other system components that prevent mid-air airplane crashes, flight control radar, ship search radar, wind sheer, traffic control and resource probe radar.

The above technology was originally developed for defense purposes in Japan and Japan is prohibited from exporting weapons under the "Three Principles of Weapon Exports." Therefore, MELCO, while checking with the Japan Defense Agency (JDA) and the Ministry of International Trade and Industry (MITI), tried to negotiate only the export of "general purpose technology" which does not violate the "Three Principles." Both JDA and MITI stated that export is no problem as long as the technology be verified to be used only for commercial purposes.

After the official contract is signed, MELCO must prepare to mass produce the system. Therefore, they are now looking into building production lines exclusively for high-power amplifiers at their Kita Itami Works and Amagasaki Communication Equipment Works.

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